APPENDIX E – Draft Noise and Vibration Study

NOISE AND VIBRATION ASSESSMENT

TUPELO MISSISSIPPI RAILROAD RELOCATION

DRAFT

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Mississippi Department of Transportation

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EXECUTIVE SUMMARY

Tupelo is a community with a population of approximately 35,000 located in the northeast region of Mississippi and is the region's major employment center. During the daytime, the population of the city multiplies between two to three times. Two rail lines pass through Tupelo, the Burlington Northern Santa Fe Railway (BNSF) main line and the Kansas City Southern Railway (KCS) branch line. The BNSF currently operates approximately 20 to 25 trains per day through the city and the KCS operates approximately 2 to 3 trains per day. The two railroads have an interchange near downtown Tupelo. There are approximately 16 at-grade highway/rail crossings near the interchange in downtown Tupelo. Congestion and delays to highway traffic are caused by the movement of trains in and through the city. It has been estimated that the volume of the BNSF trains could grow to approximately 40 trains per day in the year 2030. The KCS is estimated to grow to approximately 4 trains per day in the year 2030.

This report documents the evaluation of potential noise and vibration emissions from freight train activity on each of two proposed alternative alignments for the BNSF mainline and affected areas of the KCS branch line.

1. INTRODUCTION

The BNSF Railway Company ("BNSF") plans to construct one of two alternative alignments for the north-south mainline that transects Tupelo, Mississippi. Alternative L will abandon the portion of existing track that runs through the center of Tupelo and build a new track to the east and north of Tupelo. Alternative M will construct an elevated mainline near downtown Tupelo that will provide separated crossings at several intersections near downtown Tupelo. Both alternatives will also include operational improvements to allow for the exchange of BNSF and KCS cars south of the downtown area. The alternatives are discussed in more detail below.

Alternative L is approximately 25.6 miles long and would leave the existing BNSF line north of MS 178, cross under MS 178 then parallel Town Creek and cross under the Coley Road Extension and Mount Vernon Road. The alignment would cross over Yonaba Creek, Natchez Trace Parkway and Town Creek as part of a long bridge structure (approximately 4,400 feet). The alignment then turns south to cross over US 78 via a 400 feet bridge. The alternative crosses over both Gloster Street and US 45 as part of another long bridge structure (approximately 3,500 feet). It would then cross over the KCS line, continue south, cross over Main Street, and merge with the BNSF line. Approximately 10.7 miles of new track, including approximately 9,350 feet of rail bridges for roadway and rail crossings would be constructed for Alignment L. Thus, approximately 14.9 miles of existing track would not require additional improvements. The length of rail bridges and trestle required to span floodplains and other water features would be approximately 10,360 feet.

This alternative will eliminate 14 at-grade roadway crossings and the BNSF/KCS railroad crossing in Tupelo; The at-grade roadway crossings will include Endville Rd., Colonial Estates Rd., Trace Ave., Jackson St., Blair St., Jefferson St., Park St., Gloster St., Main St., Church St., Green St., Spring St., Elizabeth St. and the KCS crossing at Eason Blvd.

Alternative M consists of an elevated rail viaduct within the existing railroad right-of-way, to grade separate the BNSF line over the at-grade road crossings through Tupelo and the KCS line. The route would parallel the existing track, except where modified curvature will allow trains to travel at 40 mph. The Alternative is approximately 2.85 miles long and would begin the elevation change east of the Natchez Trace Parkway and remain elevated until near the US 45 grade separation. The length of rail bridge will be approximately 1,200 feet minimum, but is expected to increase to approximately 7,500 feet based upon visual impacts from Blair Street to the KCS crossing.

Alternative M would eliminate the BNSF/KCS interchange and 11 at-grade roadway crossings; BNSF (Jackson St., Blair St., Jefferson St., Park St., Gloster St., Main St., Church St., Green St., Spring St., Elizabeth St.) and KCS (Eason Blvd.).

Operational Improvements (Both Proposed Alternatives)
The amount of rail traffic through Tupelo contributes directly to the auto traffic delay and safety concerns at the at-grade crossing locations. A portion of the delay occurring in-town is due to the exchange of rail cars between BNSF and KCS. This exchange of cargo, while serving the needs of the community, blocks the major north-south and east-west arterial roadways. The BNSF and KCS crossing is located approximately 3,600 feet east of the Main Street and Gloster Street at-grade intersection (locally known as Crosstown).

The proposed operational improvement would move the interchange to the southeast along the BNSF line. It would be located south of the Pvt. John Allen National Fish Hatchery and north of US Highway 45. Additional three (3) rail storage tracks, turnouts and electric lock-out switches would be constructed along both BNSF and KCS lines for the exchange of rail cars. Roadway improvements which would also reduce auto traffic delay and remove potential rail and vehicular conflicts would be the grade separation of Eason Boulevard at both the BNSF and KCS crossings. The existing highway overpass for US Highway 45 would also require reconstruction to facilitate the additional storage track.

1.1 Assessment Approach

This analysis is based on FTA and FRA guidance documents. Following is a general outline of the approach used for noise & vibration analyses.

1. **Identify potential sensitive receptors**: The term “sensitive receptors” normally is used to refer to land uses such as residences, schools, and churches. Representative locations of sensitive receptors were identified through a site visit to the project area and through examining aerial photographs.
2. **Determine appropriate impact thresholds**: This includes the standard criteria for human exposure to rail related noise and vibration.
3. **Document existing conditions:** Noise and vibration measurements were performed at several representative locations within the project area.
4. **Develop noise and vibration prediction models**: The noise measurement results were used to develop models of train noise based on the Federal Transit Administration (FTA) document, “Transit Noise and Vibration Impact Assessment” (FTA report FTA-VA-90-1003-06 May 2006), referred to herein as the FTA Guidance Manual with input parameters including distance from the tracks to sensitive receptors, train speed, and average train consist and daily train volumes. The vibration

prediction model was based on the vibration screening methodology contained in the FTA methodology with input parameters including, average train consist and daily train volumes, train speeds and adjustment factors such as, track condition, special trackwork, path and receiver characteristics.

5. **Predict potential impacts**: The prediction models were used along with the forecasted operations provided by BNSF to estimate future noise and vibration levels at each sensitive receptor.

1.2 Noise and Vibration Sources from BNSF Operations in Tupelo

Following is a discussion of the primary noise and vibration sources from freight train operations in Tupelo.

Locomotive engines: Noise from the locomotive engine is caused by the engines, cooling fans, and exhaust. The locomotive reference noise level used in this analysis was based on pass-by noise monitoring data collected in the project area.

Wheel/rail noise: This noise is caused by the interaction of the train's steel wheels rolling on the steel rails. This noise increases with speed and can be relatively low up to speeds of approximately 60 mph for trains operating on tangent (straight) track with wheels and rails that are in good condition. Factors that increase levels of wheel-rail noise are wheel squeal on tight radius curves, wheel impacts at rail joints, and poor condition of the wheel or rail operating surface. The currently existing and proposed tracks on the BNSF mainline are continuously welded rail (i.e. no rail joints) and do not operate through any tight corners. A portion of the KCS branchline located north of Tupelo contains jointed rail, however this area is located outside of the area affected by the project and is therefore not included in the noise analysis.

Wheel/rail vibration: Vibration from trains is caused by the wheels rolling on the rails. The forces caused by the interaction of the wheels, rails and trackbed cause vibration in the ground that propagates away from the track. When there are residences 200 feet or less from the tracks, the ground vibration interacting with building structures will sometimes cause perceptible vibration of the floors and walls of living spaces or rattling of windows, items on shelves, or items hanging on walls. It is very unusual for train generated vibration to be sufficient to cause even minor cosmetic damage to buildings. Vibration levels will increase at special trackwork for switches and turnouts because of wheel impacts where two rails cross. Note that standard practice for BNSF is to use continuously welded rail on it's mainline. This eliminates the additional vibration that can be generated by wheel impacts at rail joints.

Train horns: Federal Railroad Administration (FRA) regulations require that the lead locomotive be equipped with an audible warning device that generates a minimum of 96 dBA at 100 ft from the front of the locomotive and a maximum of 110 dBA. On freight trains, the warning device is usually a set of air horns mounted on the top of the lead locomotive. FRA regulations require sounding the train horn prior to all at-grade rail/highway crossings, otherwise the horn is used only when the locomotive engineer perceives that an audible warning is needed. Train horns are currently used throughout Tupelo at all at-grade roadway crossings and at the BNSF/KCS intersection at the southeast end of town.

2. NOISE AND VIBRATION CRITERIA

The criteria used to assess each type of potential noise and vibration impact are discussed in the following sections.

2.1 Sensitive Receptors

This category includes traditional noise sensitive receptors such as residences, schools, libraries, and churches. Criteria for noise and vibration impacts from federally-funded transit projects are usually based on criteria given in the FTA Guidance Manual. The FTA noise criteria are founded on well-documented research on community reaction to noise. Virtually identical noise and vibration impact criteria are included in the recently released Federal Railroad Administration (FRA) document “High-Speed Ground Transportation Noise and Vibration Impact Assessment” (October 2005).

The FRA/FTA noise and vibration impact criteria are summarized below:

Noise Impact

Designed to prevent annoyance, the FTA criteria take into account (1) the startle effect on humans and wildlife, and (2) the noise sensitivity of different land uses. Table 1 includes a description of the three categories FTA used for noise-sensitive land uses and the applicable noise metric for each land use category. The residences in the vicinity of Tupelo, Mississippi are considered as Category 2. Outdoor day-night sound level (Ldn)[1] is the noise metric used by FTA criteria for Category 2 land uses. Category 1 includes areas that have been officially designated as parks where “quiet is an essential element of their intended purpose.” None of the areas within the project area have been designated as such. Although portions of the project area include undeveloped rural landscapes, these areas were given a more sensitive Category 2 land use classification for purposes of this analysis. The predicted impact levels may therefore be considered conservative in these areas.

The FTA noise criteria are a sliding scale as shown in Figure 1. The existing noise is shown on the horizontal axis and the amount of new noise created by the project is shown on the vertical axis. For Category 2 land uses, the left vertical axis is used and noise exposure is measured using Ldn. The right vertical axis is used for Category 3 land uses and noise exposure for Category 3 land uses is measured using hourly average sound level (Leq(h)). The basic concept of the FTA noise impact criteria is that more project noise is allowed to be added in areas where existing noise is higher, but that the decibel increase in total noise exposure (existing noise plus project noise) decreases.[2] This means that noise from the existing BNSF operations are part of the existing environment and affect the threshold for noise impact. Note that the FTA noise impact criteria are applied at the closest sensitive receptor, which generally means the closest sensitive human land use.

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[1] See Appendix A for definitions of key technical terms used in this report.

[2] As discussed in the Appendix, noise is measured on a logarithmic scale such that the existing noise and the project noise in decibels cannot be added directly to one another.

Table 1. FTA/FRA Land Use Categories and Noise Metrics

Land Use Category	Noise Metric[1] (dBA)	Description of Land Use Category
1	Outdoor Leq(h)[2]	A tract of land where quiet is an essential element of their intended purpose. This includes lands set aside for serenity and quiet and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use.
2	Outdoor Ldn	Residences and buildings where people normally sleep. This includes homes, hospitals and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor Leq(h)[2]	Institutional land uses with primarily daytime and evening uses. This includes schools, libraries, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Buildings with interior spaces where quiet is important, such as medical offices, conference rooms, recording studios and concert halls fall into this category, as well as places for meditation or study associated with cemeteries, monuments, museums. Certain historical sites, parks and recreational facilities are also included.

(1) For certain uses other than freight trains, “onset-rate” adjusted sound levels (Leq, Ldn) are used. There is no “onset-rate” adjustment for freight trains.

(2) Leq for the noisiest hour of transit-related activity during hours of noise sensitivity.

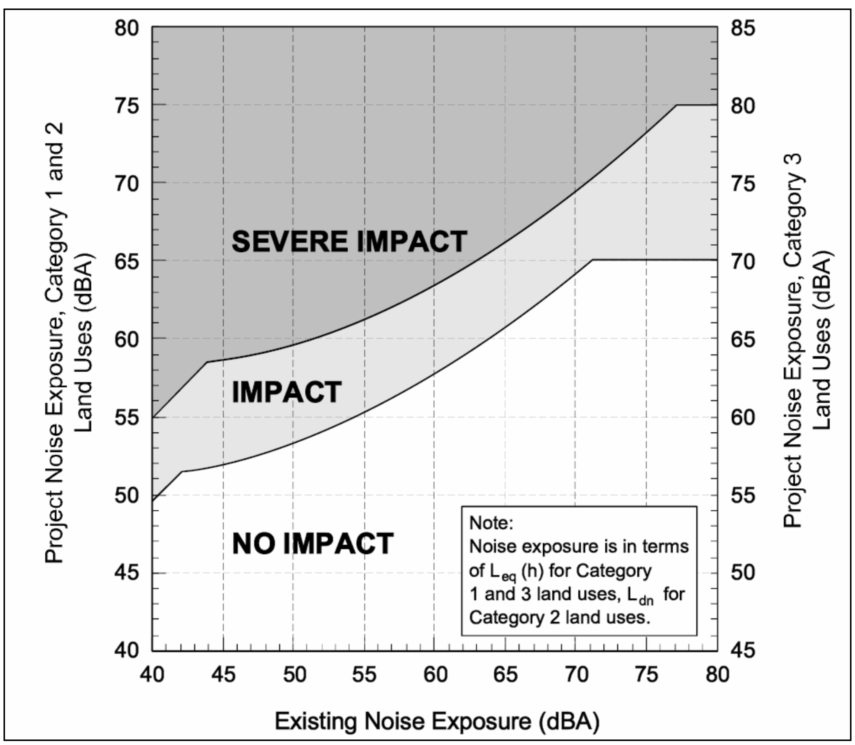


Figure 1. FTA and FRA Noise Impact Criteria

Vibration Impact

The FTA/FRA vibration criteria also are designed to prevent annoyance from operations and are far below the damage thresholds for normal structures. The impact thresholds are based on the maximum RMS ground vibration caused by a typical train pass by, and are lower for frequent events than for infrequent events. FTA defines "frequent" service to be more than 70 vibration events per day. Because the BNSF trains average more than 3 locomotives and more than 70 cars per day, through Tupelo, the frequent criteria were applied to both the locomotives and rail cars for the project. The KCS trains which average 2 trains per day with typically less than 70 cars were considered to be infrequent events.

Similar to the FTA noise criteria, the FTA vibration criteria are based on three land use categories, although the categories are slightly different than for noise. One important difference is that FTA did not include outdoor spaces in Category 3 for vibration. This is because human annoyance from ground-borne vibration typically requires the interaction of the ground vibration with a building structure.

Table 2 shows FTA/FRA criteria for ground-borne vibration from rail systems. The values in Table 2 are in terms of decibel units termed vibration decibels with a reference unit of 1 micro-inch per second (VdB).

Table 2. FTA/FRA Impact Thresholds for Ground-Borne Vibration

Land Use Category	Vibration Impact Levels (VdB re 1 µin/sec)	
	Frequent Events (1)	Infrequent Events (2)
Category 1. Buildings where low ambient vibration is essential for interior operations.	65	65
Category 2. Residences and buildings where people normally sleep.	72	80
Category 3. Institutional land uses with primarily daytime use.	75	83

Notes:
(1) Frequent events defined as more than 70 vibration events per day.
(2) Infrequent events defined as less than 70 events per day.

3. EXISTING CONDITIONS

Existing noise conditions in Tupelo were documented through a series of 24-hour continuous measurements performed at seven sites and short term measurements measured at two sites on May 12 through 15, 2008. The 24-hour measurements sites were selected within the project area to be representative of the sensitive receptors near the existing and proposed BNSF alignments. The short term measurements sites were located within 50 feet of the BNSF mainline to capture the pass by noise levels of BNSF trains.

3.1 24-Hour Measurement Locations

Based on a site visit and review of aerial photographs, the noise measurements were performed at the seven sites labeled 1 through 7 in Figure 2. Photographs of individual measurement sites 1 through 5 are presented in Appendix B.

Site 1 (337 King Street, Single-Family Residence): HDR performed a 24-Hour continuous measurement of noise on May 12-13, 2008 near the single-family residence located at 337 King Street adjacent to and north of the BNSF mainline ROW. This residence is near the at-grade crossings of Jefferson and Park Streets and is affected by train horn noise from north and south bound trains.

Site 2 (330 Rankin Boulevard, Single Family Residence): HDR performed a 24-Hour continuous measurement of noise on May 12-13, 2008 in the back yard of the single-family residence located at 330 Rankin Street, adjacent to and south of the BNSF mainline ROW. This residence is near the at-grade crossings of Jackson Street and Rankin Boulevard and is affected by train horn noise from north and south bound trains.

Site 3 (130 Madison Street, Madison Arms Apartments): HDR performed a 24-Hour continuous measurement of noise on May 12-13, 2008 near the Madison Arms Apartments located adjacent to and north of the BNSF mainline ROW. The apartments are near the at-grade crossings of Church and Green Streets and are affected by train horn noise from north and south bound trains.

Site 4 (Heardtown Estates, Residential Development, County Road 1740): HDR performed a 24-Hour continuous measurement of noise on May 12-13, 2008 near the entrance to the Heardtown Estates Residential Development located along County Road 1740. This area is located to the north of the proposed Alternative L alignment. The surrounding area is rural with the primary noise sources identified as roadway traffic and agricultural activities.

Site 5 (1505 Trace Avenue, Single Family Residence): HDR performed a 24-Hour continuous measurement of noise on May 13-14, 2008 in the side yard of the single-family residence located at 1505 Trace Avenue, north of the BNSF mainline ROW. This residence is near the at-grade crossing of Trace Avenue and is affected by train horn noise from north and south bound trains.

Site 6 (Abby Lane, Single Family Residence): HDR performed a 24-Hour continuous measurement of noise on May 13-14, 2008 near a single-family residence located on Abby Lane adjacent to and north of the BNSF mainline ROW. This residence is near the at-grade crossing of Endville Road and is affected by train horn noise from north and south bound trains.

Site 7 (Hilda Avenue, Single Family Residence): HDR performed a 24-Hour continuous measurement of noise on May 14-15, 2008 near a single-family residence located on Hilda Avenue adjacent to and west of the KCS branch line and proposed BNSF Alternative L alignment. The surrounding area is primarily undeveloped with noise sources identified as roadway traffic and KCS train pass bys.

Figure 2. Aerial Photograph Showing Project Area and Measurement Sites

3.2 24-Hour Noise Measurement Results

As discussed above, the noise monitoring consisted of continuous 24-hour measurements at seven sites in the Tupelo, Mississippi project area (Sites 1-7). The project team collected the 24-hour noise monitoring data using Larson Davis 820 sound level meters (Appendix C). Twenty-four consecutive one-hour Leq measurements were performed at these locations, and an Ldn was determined at each site. The results of the 24-hour noise measurements are summarized in Table 3.

Table 3. 24-Hour Noise Monitoring Data

Receptor ID	Location	Land Use Category/ Noise Metric	Measured Ldn	FTA Moderate Impact Threshold (Ldn)	FTA Severe Impact Threshold (Ldn)
Site 1	337 King Street - Residence	2/ Outdoor Ldn	82	66 dBA	75 dBA
Site 2	330 Rankin Boulevard - Residence	2/ Outdoor Ldn	83	66 dBA	75 dBA
Site 3	130 Madison Street - Madison Arms Apartments	2/ Outdoor Ldn	72	66 dBA	71 dBA
Site 4	Heardtown Estates – Cty Road 1740	2/ Outdoor Ldn	63	60 dBA	65 dBA
Site 5	1505 Trace Avenue - Residence	2/ Outdoor Ldn	79	66 dBA	75 dBA
Site 6	Abby Lane - Residence	2/ Outdoor Ldn	78	66 dBA	75 dBA
Site 7	Hilda Avenue - Residence	2/ Outdoor Ldn	62	59 dBA	64 dBA

Existing noise levels exceed FTA's moderate noise impact thresholds at all of the monitoring locations. Existing noise levels also exceed FTA's severe noise impact thresholds at five of the seven monitoring locations.

3.3 Short-Term Measurements

In addition to looking at the overall noise levels, short term measurement data was collected to characterize the noise emissions of the freight trains. Sound Exposure Levels (SEL) were measured utilizing Larson Davis 824 and 812 Sound Level Meters at two locations within 50 feet of the BNSF mainline to characterize the noise emissions specific to the locomotives, rail cars and train horns (Appendix C). This data was then used in the Noise Prediction Model. An SEL is defined as a measure of the total acoustic energy of a noise event. It is a useful intermediate quantity for estimating Leq(h) and Ldn from train pass bys.

A total of 6 train pass bys were recorded during the short-term measurements. At a distance of 50 feet from the tracks, the measured SEL for locomotives ranged from 86 to 90 dBA, 96 to 105 dBA for rail cars, and 101 to 117 dBA for train horns.

4. NOISE IMPACT ASSESSMENT

Predicted noise levels for future operation of the two proposed Build alternatives and the no-build condition for the BNSF mainline through Tupelo were modeled using the measurements of noise from the existing rail line. As discussed in Section 3, those noise measurements consisted of seven 24-hour measurements and short-term measurements. The noise from the train pass bys was used to calculate the average noise generated by a single train. The future noise levels were then predicted at representative sensitive receptors based on the estimated future train volumes, consists and speeds.

The following sections summarize the noise prediction model and the predicted levels at sensitive receptors.

4.1 Noise Prediction Model Input Parameters

As discussed in Section 2, the noise impact criteria are based on the amount of additional noise that would result from the proposed project. Based on the projections by BNSF and KCS that are summarized in Table 4, by 2030 there would be an average of an additional 16 trains per day using the BNSF mainline and 3 trains per day using the KCS branch line through the project area.

Table 4. Summary of Existing and Future Train Volumes and Consists

	Existing Trains			Future Trains (2030)		
Train service	**Average number of locomotives**	**Average number of cars**	**Trains per day**	**Average number of locomotives**	**Average number of cars**	**Trains per day**
BNSF - Coal	5	135	8	6	160	13
BNSF - Freight	3	125	16	4	150	28
KCS - Through	2	95	1	3	110	3
KCS - Local	1	25	1	1	25	2

The model predicts the train noise emissions based on the train consists, volumes, train speeds, pathway between the noise source and receiver, and train horn use. The existing BNSF speeds throughout the project area vary between 20 miles per hour within downtown Tupelo to 60 mph north and south of Tupelo. Future train speeds on the elevated portion of the BNSF mainline under Alternative M are predicted to be 40 mph and 60 mph for the entire length of the Alternative L alignment. The KCS branch line existing and future speed within Tupelo is 20 mph.

4.2 Model Application

The following sections explain the development of the noise model used to evaluate future conditions in the project area. These sections define the study areas and discuss how the model was applied to evaluate future noise impacts.

To establish background noise levels for comparison to future conditions, existing 24-hour noise levels were measured at several locations in the project area. Section 3.0, Existing Conditions, describes the monitoring locations and presents the noise monitoring results.

The study area for the train activities was defined as the northern point of the BNSF rail corridor northwest of I-78 where the Alternative L alignment will re-connect with the existing BNSF mainline northwest of Tupelo. The southern terminus is southeast of Tupelo near the Veteran's Boulevard Crossing. The entire BNSF rail corridor through Tupelo, Alternative L Alignment area, and a small section of KCS branch line through Tupelo were considered affected by the project because new track alignments and grade crossing changes will occur as part of the projected project and an increase in train traffic is predicted for 2030.

The first step in the FTA noise analysis is to individually calculate a Leq(h) for locomotives, railcars, and locomotive horns, then combine them into an overall Leq(h) using the equations in Table 6-4 of the FTA manual. SEL values for locomotives and railcars used in this step were determined by collecting measurements of train pass-bys throughout the project area and are as follows: 92 dBA for locomotives and 88 dBA for railcars. The default reference SEL of 110 dBA provided in the FRA manual for locomotive horns was also used. All reference SELs are based on a distance of 50 feet from the source.

The second step in the analysis is to individually calculate a daytime Leq for locomotives, railcars, and locomotive horns, then combine them into an overall daytime Leq. Next, the nighttime Leqs for all three items are also calculated independently, and summed for an overall nighttime Leq. Using the daytime and nighttime Leq, the Ldn at 50 feet is calculated.

The third step in the moving train analysis is to evaluate the propagation path between source and receiver. The FTA manual provides calculations (FTA Table 6-5) to determine the effective path height and from it a ground factor for soft or acoustically absorptive groundcover using distance and elevation as variables. The distances between the source and receivers, the terrain features and elevations in the proposed project area were confirmed by evaluating digital aerial photographs using Arcview, a geographic information system, and plan drawings. For this analysis, the equation for calculating the effective source height for a source and receiver on flat ground was used throughout the corridor except in the area of the proposed elevated track alignment under Alternative M. Results of this analysis can be considered to be conservatively high in areas where the terrain between the proposed tracks and the nearest receptors are not completely flat.

The fourth step in the moving train analysis evaluated the shielding of wayside or grade-crossing noise provided by the first and subsequent rows of buildings adjacent to the rail corridor. During the final step, the existing noise levels were compared to predicted future freight and passenger generated noise levels for the Build Alternatives to determine project related noise impacts.

4.3 Predicted Noise Impacts

4.3.1 No Build

Train volumes are predicted to increase to approximately 40 trains per day on the BNSF mainline through Tupleo and to approximately 4 trains on the KCS branch line by the build year of 2030. The No-Build Alternative was modeled using the projected train traffic data, with train consist information as shown in Table 4, to determine distances to the wayside noise impact contours and to the grade-crossing noise impact contours where train horns are used. Figures 3A-E present the noise impact contours for the No-Build condition.

Four hundred fourteen (414) noise impacts, 128 of which are classified as severe were identified under the No Build Alternative. Table 5 summarizes the number of impacts by project area location.

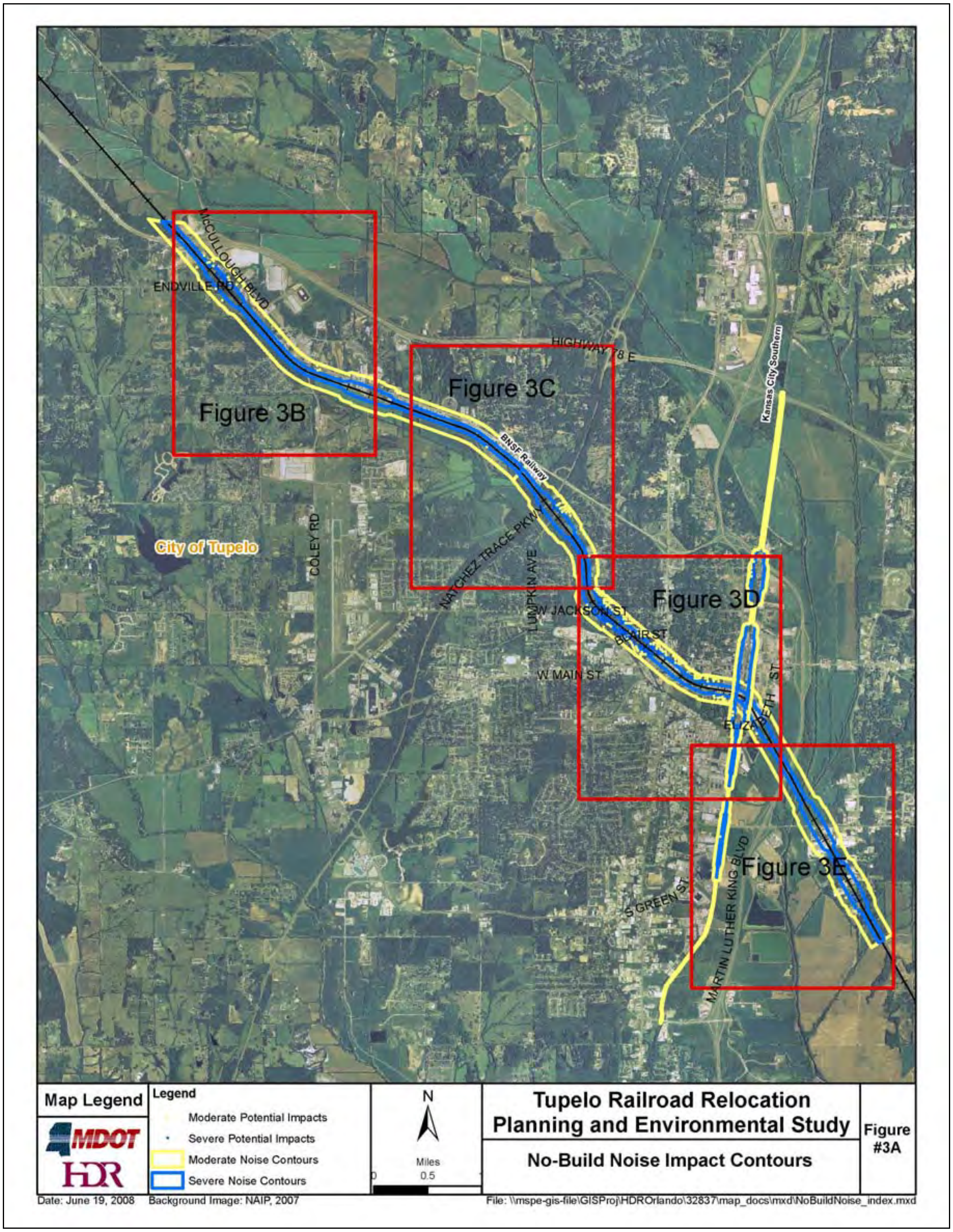
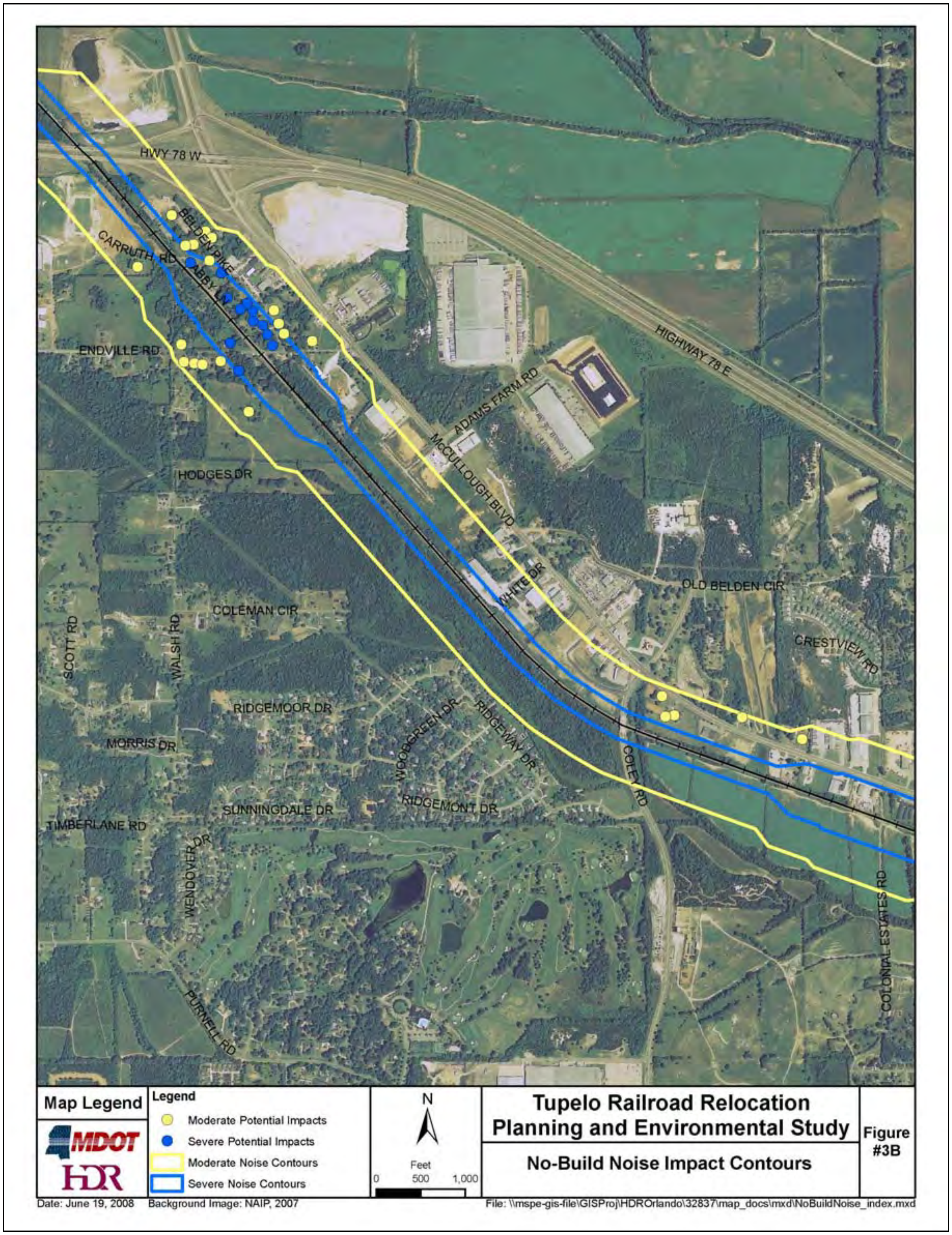


Figure 3 A-E. No-Build Noise Impact Contours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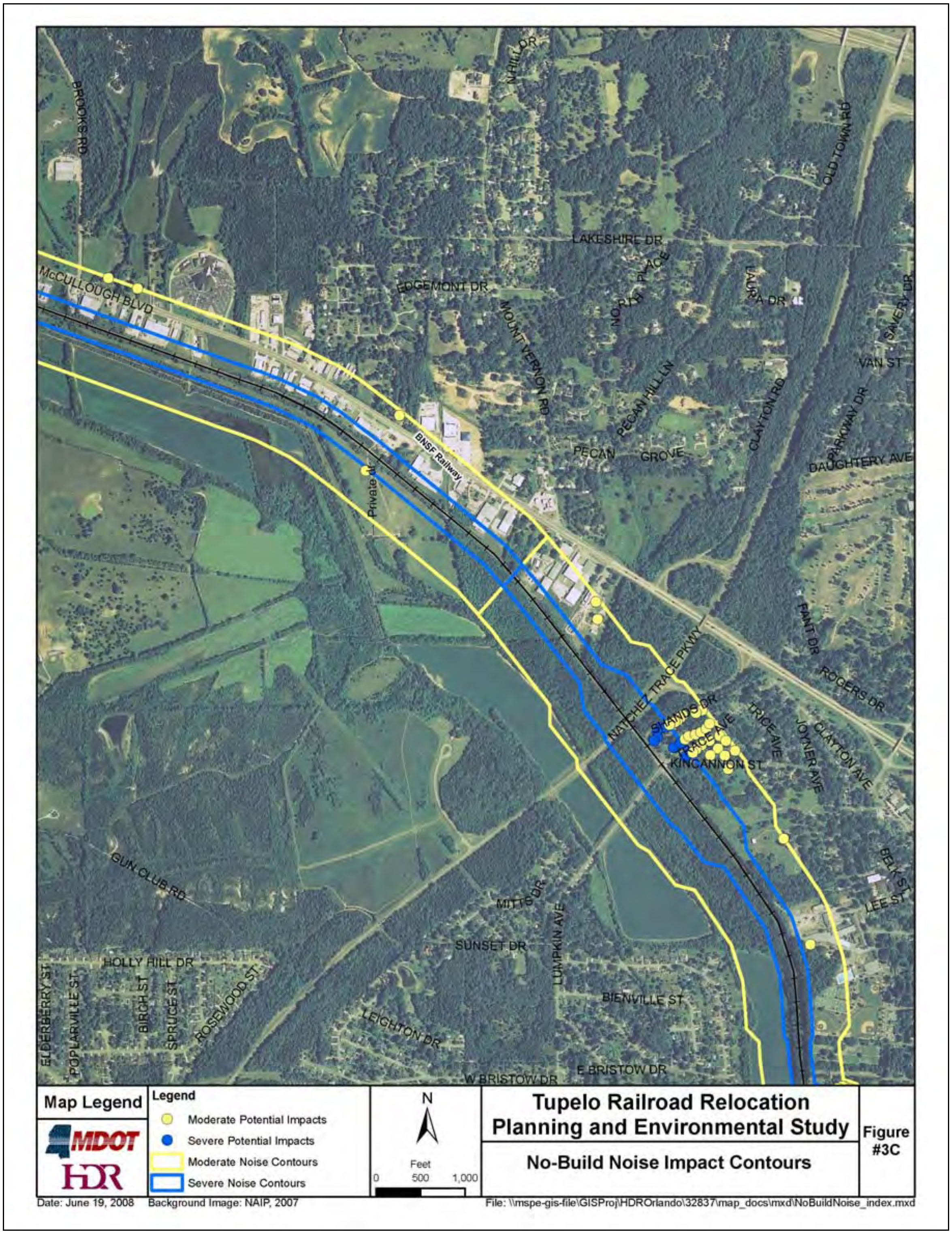
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SUNSET DR
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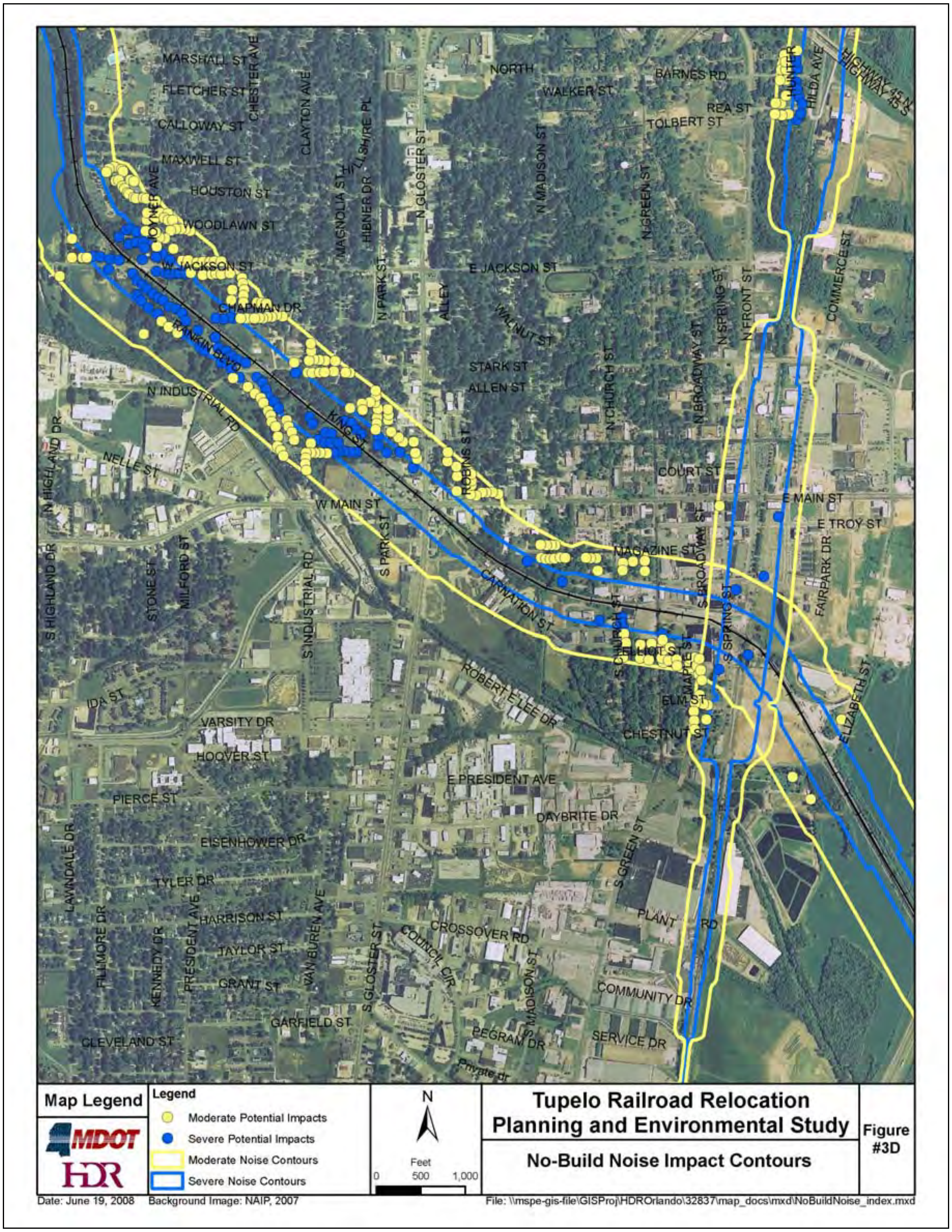
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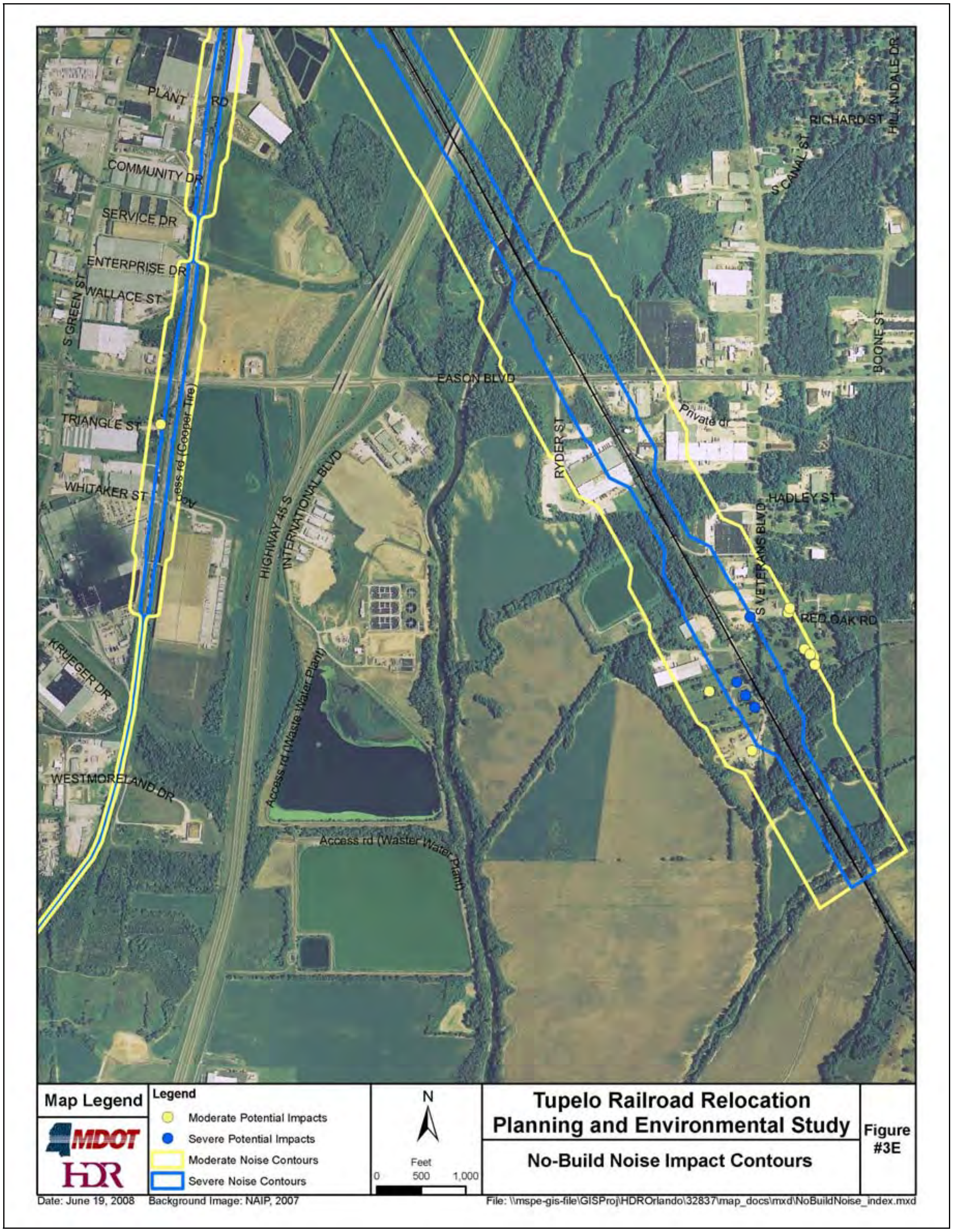
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File: \\mspe-gis-file\GISProj\HDROrlando\32837\map_docs\mxd\NoBuildNoise_index.mxd

E.

4.3.2 Alternative M (Elevated BNSF Mainline)

Alternative M was modeled using train traffic projected for the Build year of 2030 to determine distances to the wayside noise impact contours and to the grade-crossing contours where train horns are used. Figures 4A-E present the contours for Alternative M. Under Alternative M, the mainline will be elevated and grade separated through downtown Tupelo eliminating 11 grade crossings and the BNSF/KCS interchange causing a decrease in predicted Ldn levels and impacted receivers when compared to the No-Build condition due to a decrease in train horn use.

Three hundred eighty-five (385) noise impacts, 76 of which are classified as Severe, were identified for Alternative M. Table 5 summarizes the number of noise impacts by project area location.

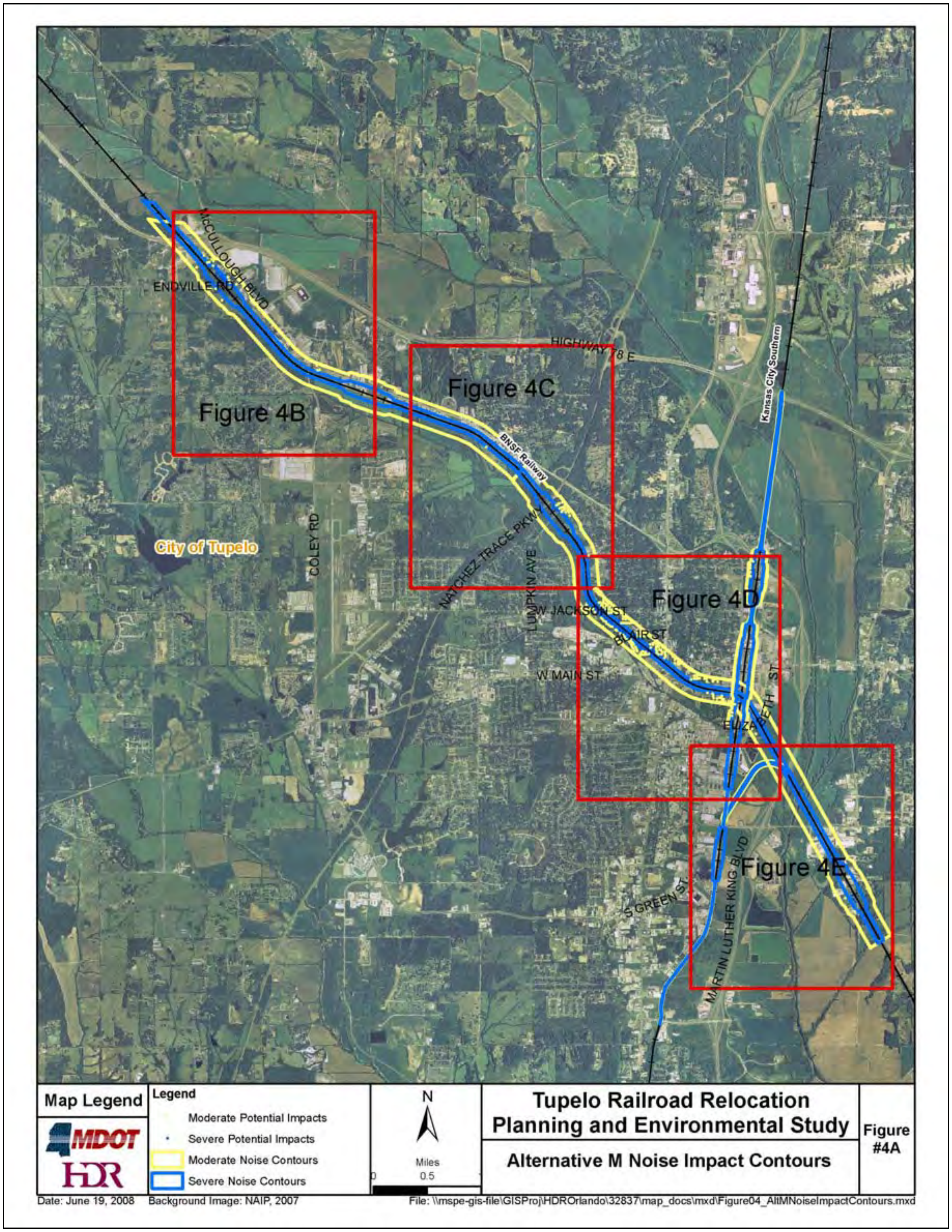
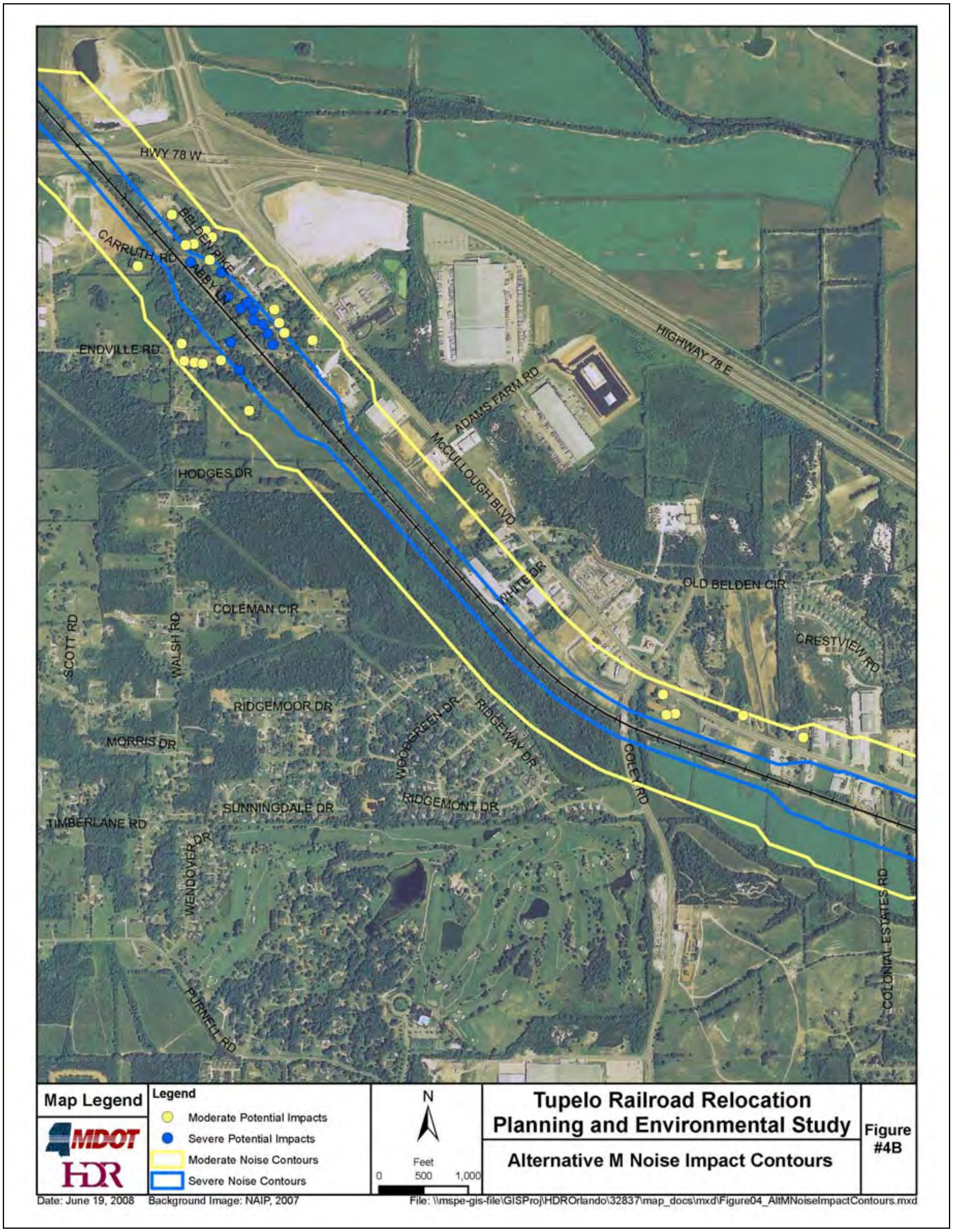


Figure 4 A-E. Alternative M Noise Impact Contours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HIGHWAY 78 E
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CARRUTH RD
ABBY LN
ENDVILLE RD
ADAMS FARM RD
McCULLOUGH BLVD
HODGES DR
WHITE DR
OLD BELDEN CIR
COLEMAN CIR
CRESTVIEW RD
SCOTT RD
WALSH RD
RIDGEMOOR DR
WOODGREEN DR
RIDGEWAY DR
MORRIS DR
COLEY RD
SUNNINGDALE DR
RIDGEMONT DR
TIMBERLANE RD
WENDOVER DR
COLONIAL ESTATES RD
PURNELL RD
Map Legend
Legend
Moderate Potential Impacts
Severe Potential Impacts
Moderate Noise Contours
Severe Noise Contours
MDOT
HDR
N
Feet
0 500 1,000
Tupelo Railroad Relocation
Planning and Environmental Study
Alternative M Noise Impact Contours
Figure #4B
Date: June 19, 2008
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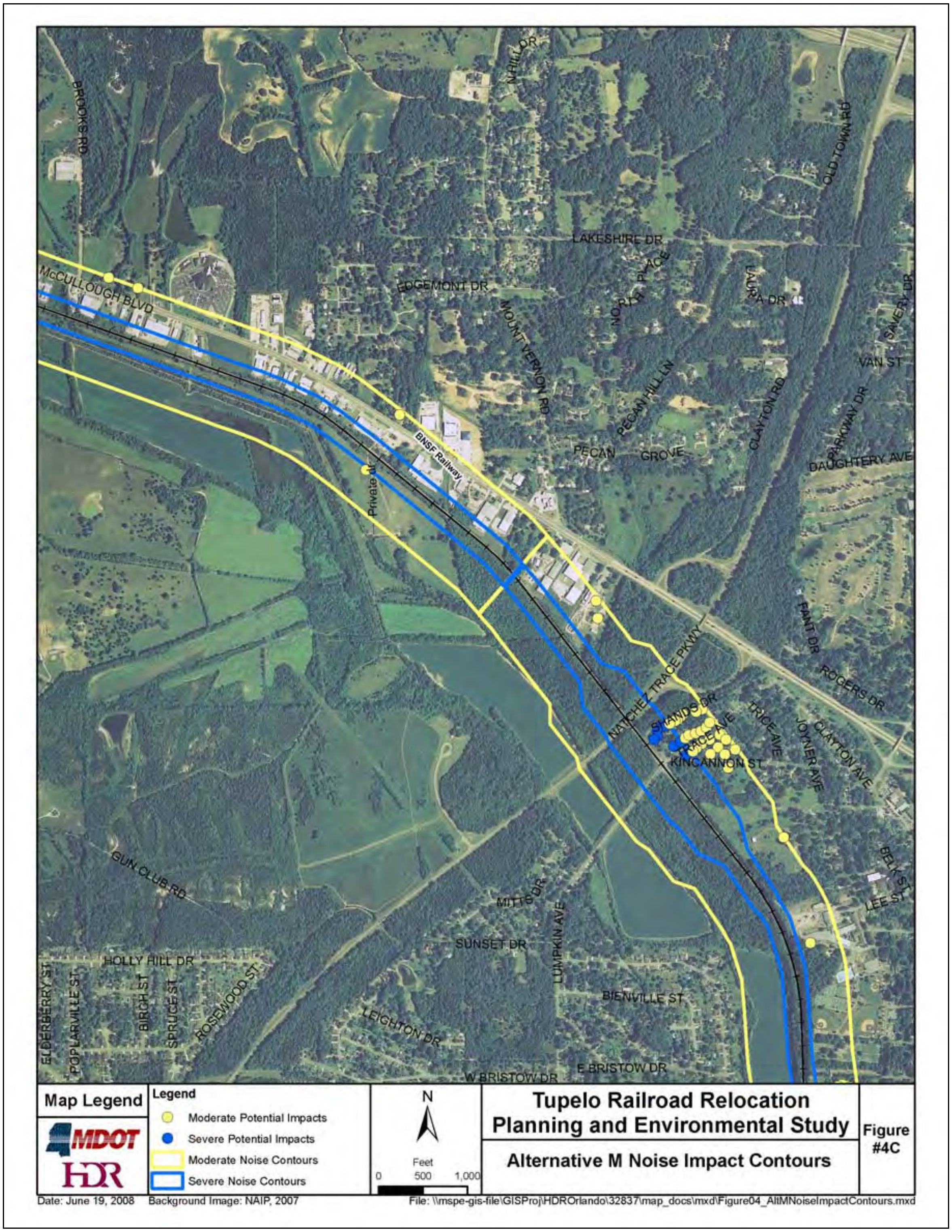
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HDR
Legend
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Severe Potential Impacts
Moderate Noise Contours
Severe Noise Contours
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Feet
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Tupelo Railroad Relocation Planning and Environmental Study
Alternative M Noise Impact Contours
Figure #4C
Date: June 19, 2008
Background Image: NAIP, 2007
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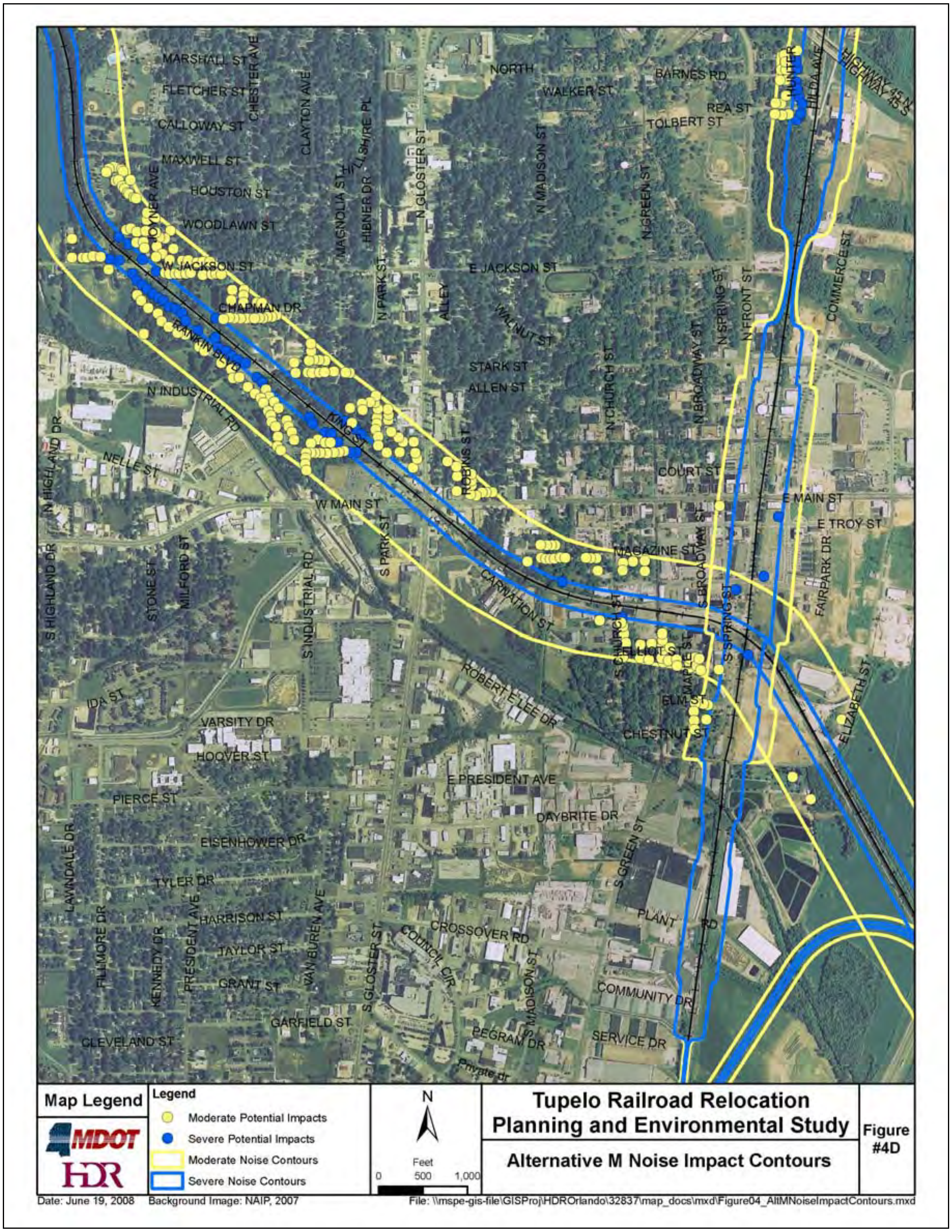
BNSF Railway
McCULLOUGH BLVD
NATCHEZ TRACE PKWY
GUN CLUB RD
CLAYTON RD
OLD TOWN RD

C.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CHESTER AVE
FLETCHER ST
CALLOWAY ST
CLAYTON AVE
MAXWELL ST
HOUSTON ST
JOYNER AVE
WOODLAWN ST
W JACKSON ST
CHAPMAN DR
RANKIN BLVD
N INDUSTRIAL RD
KING ST
NELLE ST
N HIGHLAND DR
W MAIN ST
S HIGHLAND DR
STONE ST
MILFORD ST
S INDUSTRIAL RD
S PARK ST
N PARK ST
ALLEY
N GLOSTER ST
HIENER DR
MAGNOLIA ST
NORTH
WALKER ST
BARNES RD
REA ST
TOLBERT ST
N MADISON ST
N GREEN ST
E JACKSON ST
WALNUT ST
STARK ST
ALLEN ST
ROBINS ST
N CHURCH ST
N BROADWAY ST
N SPRING ST
N FRONT ST
COMMERCE ST
HILDA AVE
HUNTER
HIGHWAY 45 N
HIGHWAY 45 S
COURT ST
E MAIN ST
E TROY ST
FAIRPARK DR
MAGAZINE ST
S BROADWAY ST
S SPRING ST
CARNATION ST
S CHURCH ST
ELLIOT ST
MAPLE ST
ELM ST
CHESTNUT ST
ELIZABETH ST
ROBERT E LEE DR
IDA ST
VARSITY DR
HOOVER ST
PIERCE ST
E PRESIDENT AVE
DAYBRITE DR
S GREEN ST
LAWNDALE DR
EISENHOWER DR
TYLER DR
FILLMORE DR
KENNEDY DR
PRESIDENT AVE
HARRISON ST
TAYLOR ST
VAN BUREN AVE
GRANT ST
S GLOSTER ST
COUNCIL CIR
CROSSOVER RD
S MADISON ST
PLANT RD
COMMUNITY DR
GARFIELD ST
CLEVELAND ST
PEGRAM DR
SERVICE DR
Private dr
Map Legend
MDOT
HDR
Legend
Moderate Potential Impacts
Severe Potential Impacts
Moderate Noise Contours
Severe Noise Contours
N
Feet
0 500 1,000
Tupelo Railroad Relocation
Planning and Environmental Study
Alternative M Noise Impact Contours
Figure
#4D
Date: June 19, 2008
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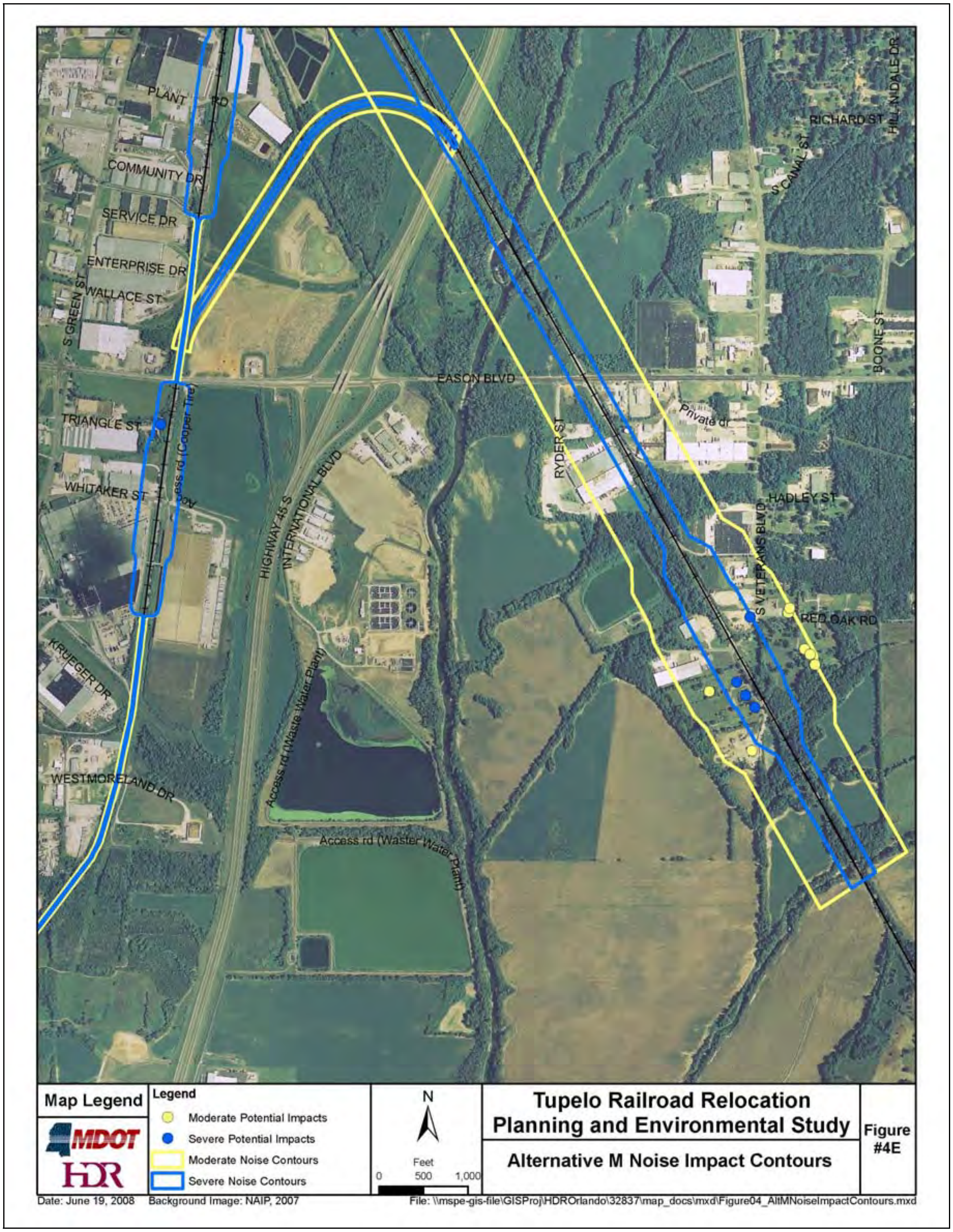
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COMMUNITY DR
SERVICE DR
ENTERPRISE DR
WALLACE ST
S GREEN ST
EASON BLVD
TRIANGLE ST
WHITAKER ST
KRUEGER DR
WESTMORELAND DR
HIGHWAY 45 S
INTERNATIONAL BLVD
Access rd (Waste Water Plant)
Access rd (Waster Water Plant)
RYDER ST
Private dr
HADLEY ST
S VETERANS BLVD
RED OAK RD
BOONE ST
RICHARD ST
S CANAL ST
HILLANDALE DR
Map Legend
MDOT
HDR
Legend
Moderate Potential Impacts
Severe Potential Impacts
Moderate Noise Contours
Severe Noise Contours
N
Feet
0 500 1,000
Tupelo Railroad Relocation
Planning and Environmental Study
Alternative M Noise Impact Contours
Figure #4E
Date: June 19, 2008
Background Image: NAIP, 2007
File: \\mspe-gis-file\GISProj\HDROrlando\32837\map_docs\mxd\Figure04_AltMNoiseImpactContours.mxd

E.

4.3.3 Alternative L

Alternative L was modeled using train traffic projected for the Build year of 2030 to determine distances to the wayside noise impact contours and to the grade-crossing contours where train horns are used. Figures 5A-E present the contours for Alternative L. Under Alternative L, the mainline will be relocated to the east and north of Tupelo eliminating the mainline track, 14 grade crossings and the BNSF/KCS interchange in the town of Tupelo.

Two hundred twenty-two (222) noise impacts, 22 of which are classified as Severe, were identified for Alternative L. Table 5 summarizes the number of noise impacts by project area location.

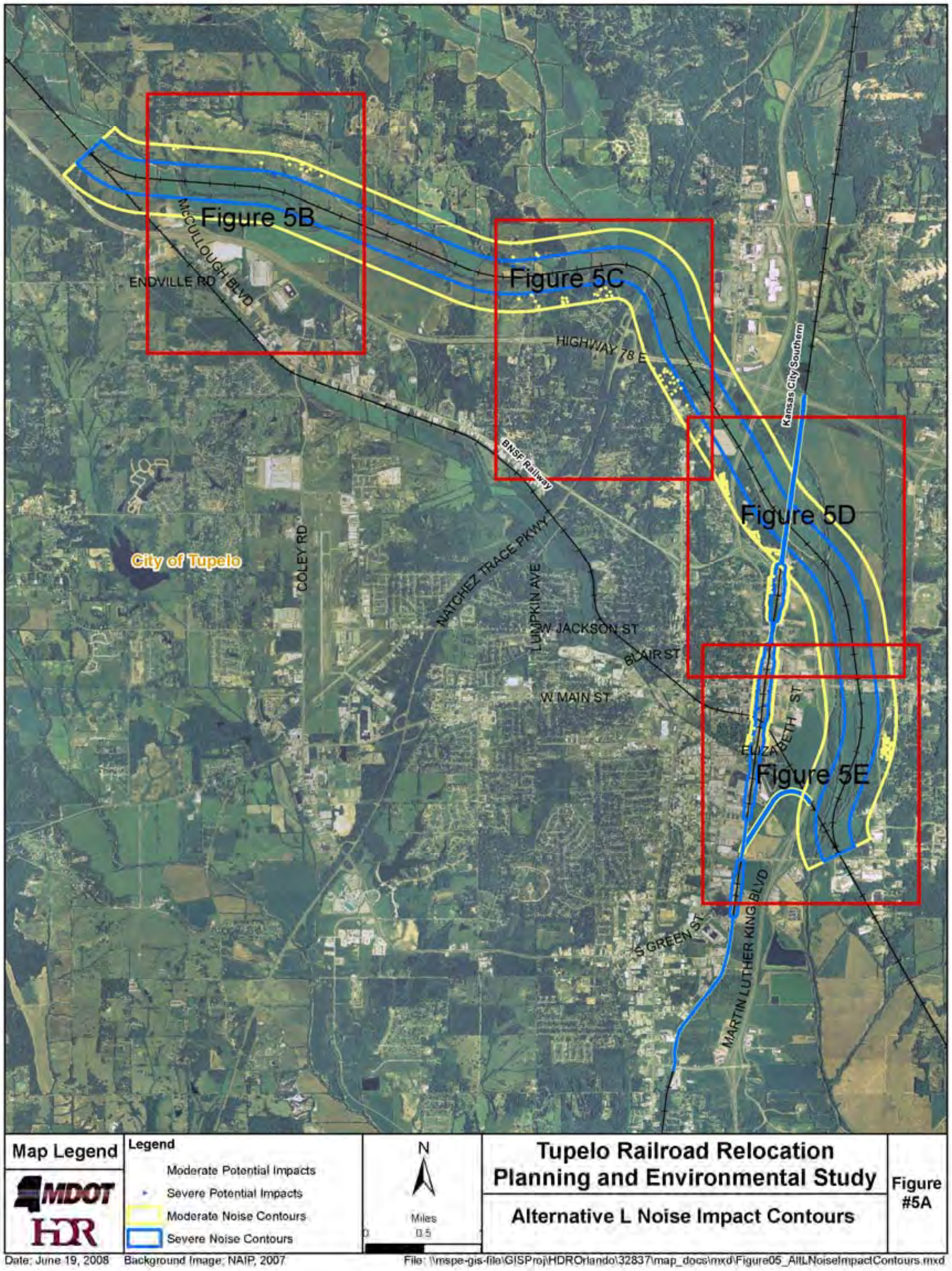
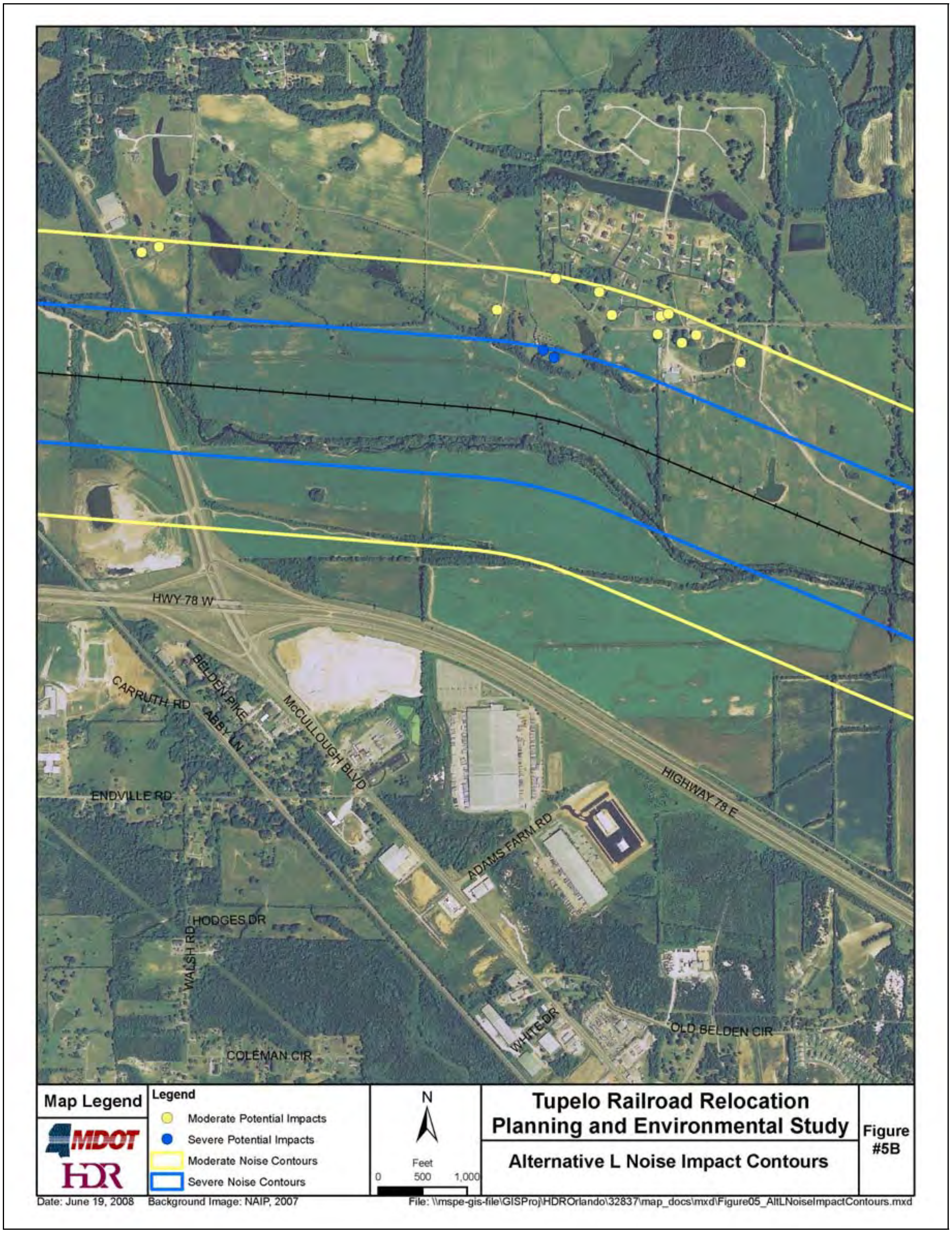


Figure 5 A-E. Alternative L Noise Impact Contours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BELDEN PIKE
ABBY LN
McCULLOUGH BLVD
HIGHWAY 78 E
ENDVILLE RD
ADAMS FARM RD
HODGES DR
WALSH RD
WHITE DR
OLD BELDEN CIR
COLEMAN CIR
Map Legend
Legend
Moderate Potential Impacts
Severe Potential Impacts
Moderate Noise Contours
Severe Noise Contours
MDOT
HDR
N
Feet
0 500 1,000
Tupelo Railroad Relocation
Planning and Environmental Study
Alternative L Noise Impact Contours
Figure #5B
Date: June 19, 2008
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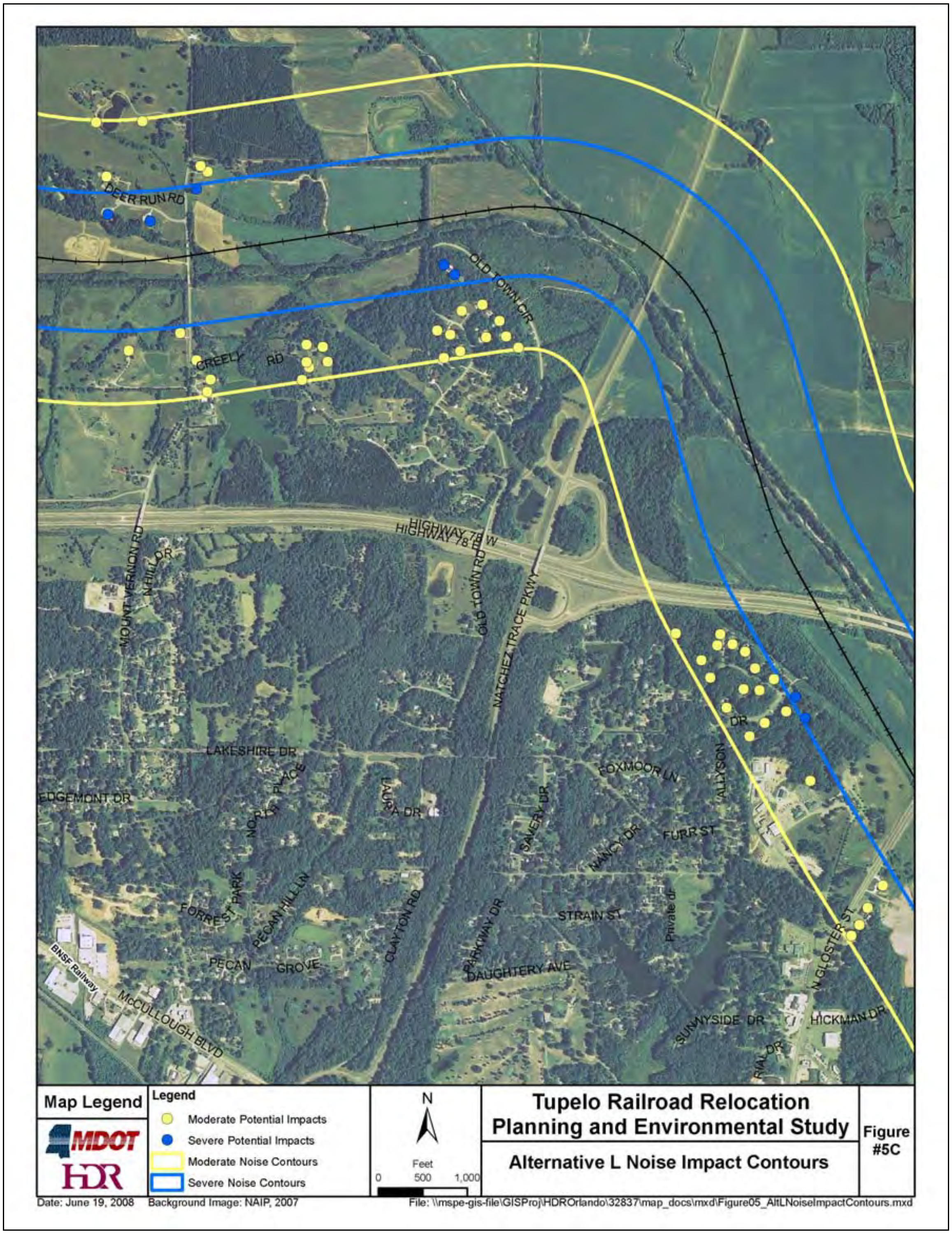
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CREELY RD
OLD TOWN CIR
HIGHWAY 78 E
HIGHWAY 78 W
MOUNT VERNON RD
N HILL DR
OLD TOWN RD
NATCHEZ TRACE PKWY
LAKESHIRE DR
EDGEMONT DR
NORTH PLACE
LAURA DR
FOXMOOR LN
ALLYSON
SAVERY DR
NANCY DR
FURR ST
FORREST PARK
PECAN HILL LN
CLAYTON RD
PARKWAY DR
STRAIN ST
Private dr
N GLOSTER ST
PECAN GROVE
DAUGHTERY AVE
BNSF Railway
McCULLOUGH BLVD
SUNNYSIDE DR
HICKMAN DR
Map Legend
Legend
Moderate Potential Impacts
Severe Potential Impacts
Moderate Noise Contours
Severe Noise Contours
MDOT
HDR
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Tupelo Railroad Relocation Planning and Environmental Study
Alternative L Noise Impact Contours
Figure #5C
Date: June 19, 2008
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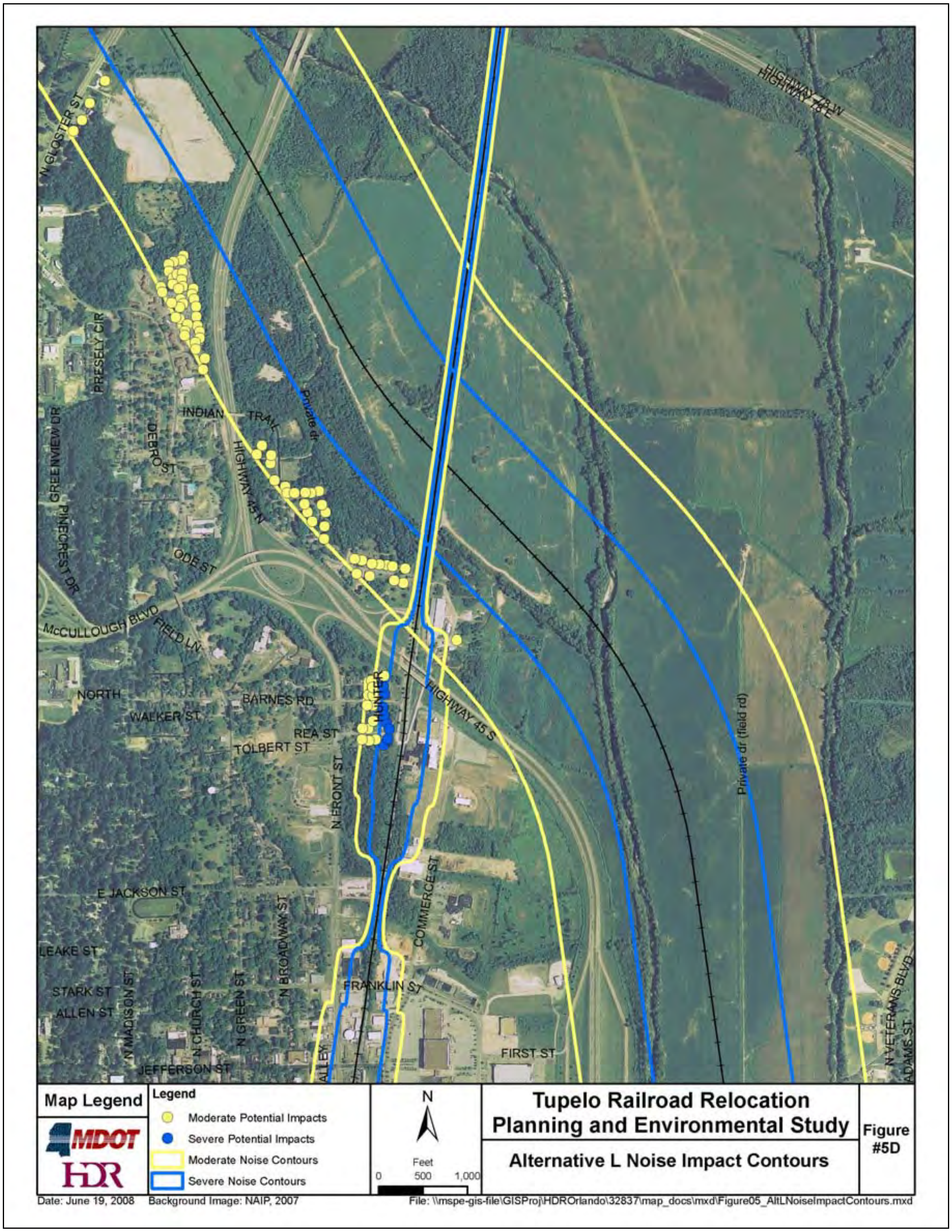
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HIGHWAY 78 W
HIGHWAY 78 E
PRESLEY CIR
GREENVIEW DR
INDIAN TRAIL
DEBRO ST
Private dr
HIGHWAY 45 N
PINECREST DR
ODE ST
McCULLOUGH BLVD
FIELD LN
NORTH
WALKER ST
BARNES RD
REA ST
TOLBERT ST
HUNTER
HIGHWAY 45 S
N FRONT ST
Private dr (field rd)
E JACKSON ST
LEAKE ST
COMMERCE ST
N BROADWAY ST
STARK ST
ALLEN ST
N MADISON ST
N CHURCH ST
N GREEN ST
FRANKLIN ST
ALLEY
JEFFERSON ST
FIRST ST
N VETERANS BLVD
ADAMS ST
Map Legend
Legend
Moderate Potential Impacts
Severe Potential Impacts
Moderate Noise Contours
Severe Noise Contours
MDOT
HDR
N
Feet
0 500 1,000
Tupelo Railroad Relocation
Planning and Environmental Study
Alternative L Noise Impact Contours
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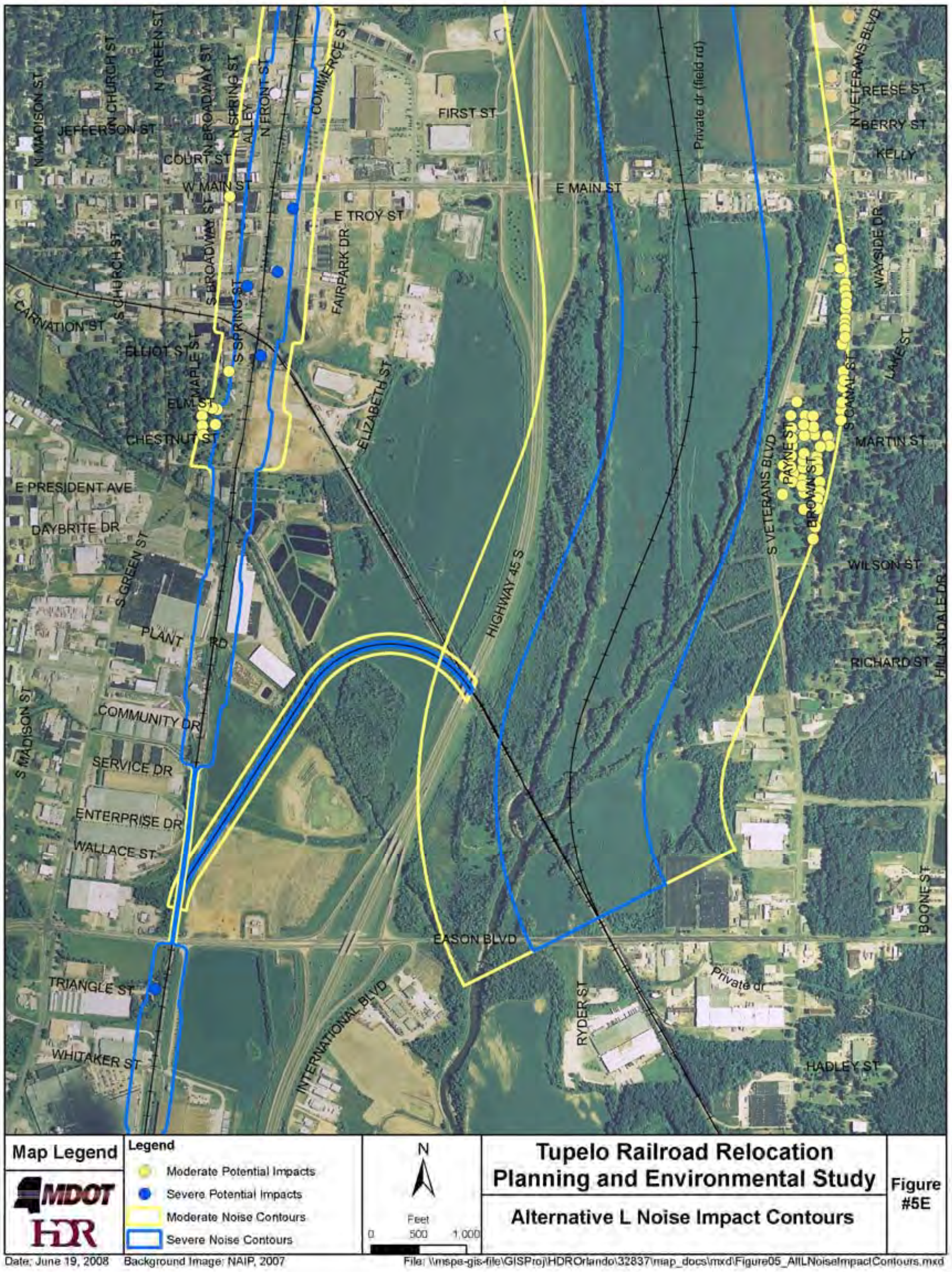

Tupelo Railroad Relocation Planning and Environmental Study
Alternative L Noise Impact Contours
Figure #5E
Map Legend
MDOT
HDR
Legend
Moderate Potential Impacts
Severe Potential Impacts
Moderate Noise Contours
Severe Noise Contours
N
Feet
0 500 1,000
Date: June 19, 2008
Background Image: NAIP, 2007
File: \\mspe-gis-file\GISProj\HDROrlando\32837\map_docs\mxd\Figure05_AltLNoiseImpactContours.mxd
FIRST ST
E MAIN ST
E TROY ST
W MAIN ST
COURT ST
JEFFERSON ST
CARNATION ST
ELLIOT ST
ELM ST
CHESTNUT ST
E PRESIDENT AVE
DAYBRITE DR
PLANT RD
COMMUNITY DR
SERVICE DR
ENTERPRISE DR
WALLACE ST
TRIANGLE ST
WHITAKER ST
EASON BLVD
HIGHWAY 45 S
INTERNATIONAL BLVD
RYDER ST
HADLEY ST
RICHARD ST
WILSON ST
MARTIN ST
REESE ST
BERRY ST
KELLY
WAYSIDE DR
S VETERANS BLVD
N VETERANS BLVD
BOONE ST
HILLANDALE DR
ELIZABETH ST
FAIRPARK DR
COMMERCE ST
N FRONT ST
N SPRING ST
N BROADWAY ST
N GREEN ST
N CHURCH ST
N MADISON ST
S MADISON ST
S GREEN ST
S CHURCH ST
S BROADWAY ST
S SPRING ST
MAPLE ST
Private dr (field rd)
Private dr

E.

Table 5. Summary of FTA Land Use Noise Impacts Predicted for No Build and Build Alternatives

Alternative	Predicted Moderate Noise Impacts (as defined by FTA)	Predicted Severe Noise Impacts (as defined by FTA)	Total Impacts	Total Benefits
No-Build	286	128	414	--
Alternative M	309	76	385	29**
Alternative L	222	22	244	170

**Does not account for 23 reductions from severe to moderate.

Analysis results show that predicted noise levels associated with Alternative M reach FTA's severe noise impact threshold at 52 fewer receptors than are predicted to occur under the No-Build Alternative. This is a net benefit associated with Alternative M. Analysis results also show an increase in the total number of moderate noise impacts under Alternative M vs. the No-Build alternative. However under this alternative, predicted noise impacts at 23 noise-sensitive receptors change from severe to moderate noise impacts (as defined by FTA). This is a benefit associated with Alternative M that a simple comparison of overall predicted noise impacts may not otherwise communicate. The noise-sensitive receptors predicted to experience noise impacts associated with Alternative M are also predicted to experience train noise levels that exceed FTA impact thresholds under the No-Build Alternative.

Analysis results show that predicted noise levels associated with Alternative L reach FTA's severe noise impact threshold at 64 fewer receptors than are predicted to occur under the No-Build Alternative. This is a net benefit associated with Alternative L. Analysis results also show a decrease in the total number of moderate noise impacts under Alternative L vs. the No-Build alternative. Finally, analysis results show a net benefit (reduction in the number of predicted noise impacts) at 170 receptors associated with Alternative L. Most of the noise-sensitive receptors predicted to experience noise impacts associated with Alternative L are not predicted to experience train noise levels that exceed FTA impact thresholds under the No-Build Alternative. In this regard, Alternative L displaces or relocates most of the noise impacts to areas that currently are not affected by train noise.

5. VIBRATION IMPACT ASSESSMENT

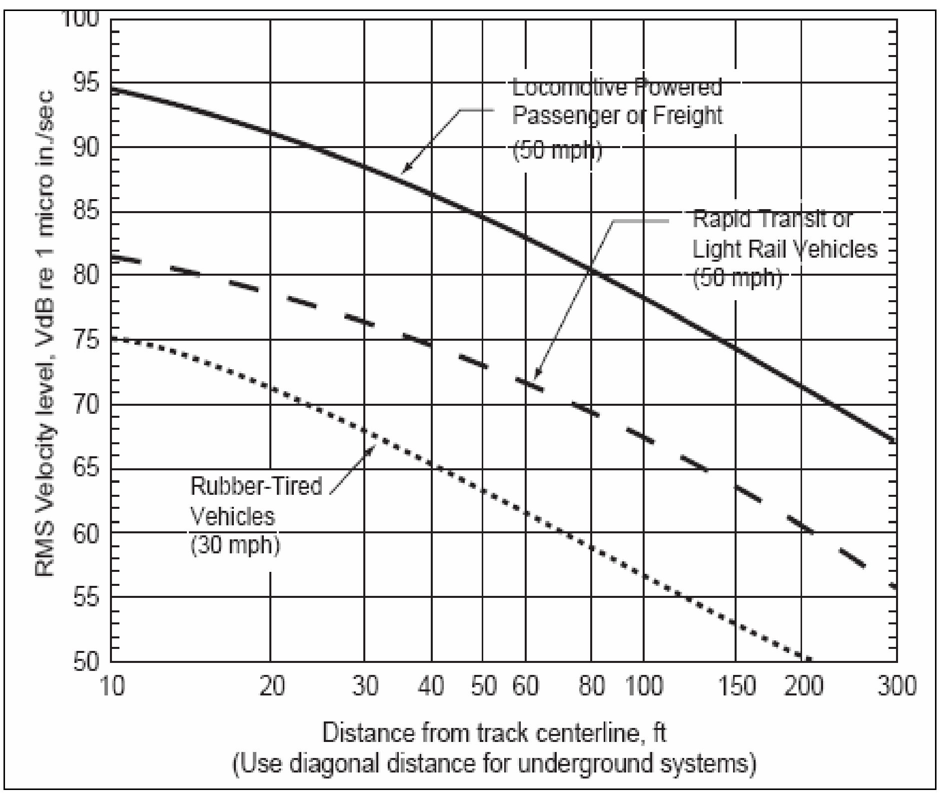
To estimate potential vibration effects from the future No-Build and Build alternatives, HDR applied the FTA General Vibration Assessment methodology to develop a prediction curve of vibration velocity as a function of distance from the tracks. This curve was used to estimate future vibration levels at each vibration sensitive receptor that were compared to vibration impact thresholds discussed in Section 2.

5.1 Vibration Prediction Model

The vibration analysis study area utilized the same area defined for the noise analysis. Vibration impacts are determined based on train speed and average number of vibration events during single train pass-bys, therefore distances to Category 2 impacts changed where track realignments and upgrades are proposed as well as where the predicted speed and number of events changed. These areas include the existing BNSF mainline and the proposed alignment under Alternative L.

The General Vibration Assessment uses generalized data to develop a curve of vibration levels as a function of distance from the track. The vibration levels at specific buildings are estimated by reading values from the curve and applying adjustments to account for factors such as track support system, vehicle speed, type of building, and track and wheel condition.

The first step in a general vibration assessment is the selection of an appropriate base curve for use in estimating project-related vibration emission levels. Figure 6 (Figure 10-1 in the FTA manual) shows the base curve options. Locomotives and railcars have different vibration emission characteristics. Diesel locomotives are typically much heavier than railcars, and therefore have greater potential to generate ground-borne vibration than railcars do. This information is used to identify the appropriate vibration emissions curve in Figure 12. The upper curve (Locomotive Powered Passenger or Freight) is representative of locomotive-induced ground-borne vibration in the project area. For the purposes of this assessment, the middle curve (Rapid Transit or Light Rail Vehicles) is considered representative of railcar-induced, ground-borne vibration in the project area.



Source: FTA, 2006.

Figure 6. Generalized Ground Surface Vibration Curves

Once the base curve has been selected, adjustments are used to develop vibration projections for specific receiver positions. The adjustment parameters include speed, wheel and rail type and condition, type of track support system, type of building foundation, geologic conditions and number of floors above the basement level. The full list of adjustment parameters is contained in Table 10-1of the FTA manual.

The adjustments for the BNSF mainline under the existing conditions, No-Build, and Build Alternatives were considered identical. However, train speeds varied throughout the project area and therefore the General Vibration Assessment applies lower adjustments to the slower train movements. In addition to the adjustment for train speed, HDR applied a conservative adjustment for ground-borne propagation effects to account for efficient propagation of the vibration from the source to the receptors throughout the project area. This adjustment adds 10 VdB to each of the vibration projections.

Because the adjusted vibration level for the locomotives is more than 10 VdB greater than the vibration level for the railcars, the railcar component of the vibration has been eliminated from further discussion.

As stated in Section 2.1 above, approximately 40 trains are predicted to travel through Tupelo on the BNSF mainline each day and 4 trains on the KCS branch line daily in 2030. This frequency of trains leads to the following ground-borne vibration impact criteria (Table 6):

Table 6. Project Specific Vibration Impact Thresholds

Location	Category Land Use	Events Classification	Vibration Impact Threshold (VdB)
BNSF Mainline	Category 2	Frequent	72
KCS Branchline	Category 2	Infrequent	80
Operational Track	Category 3	Infrequent	83

The difference between the adjusted vibration level at the screening distance and the impact threshold was then used to determine the distance to the impact contour line. By extending the base curve in Figure 6 (FTA's Figure 10-1) the distance to the vibration impact contour line for Category 2 land uses was determined to range from 60 to 170 feet from the BNSF mainline (mainly due to the range of operating speeds), and 76 feet from the KCS Branch Line. For Category 3 land uses near the proposed operational connection between the BNSF and KCS the vibration contour was determined to be 110 feet from the track connection centerline.

This vibration impact contours were overlaid upon a digital aerial photograph of the project areas using Geographic Information System (GIS) technologies. The number of residences inside the vibration contour was determined.

5.2 Predicted Vibration Impacts

5.2.1 No-Build

Twenty-eight (28) vibration impacts were identified under the No-Build Alternative. Table 7 summarizes the number of vibration impacts by location.

Figures 7A and 7B present vibration impact contours for the No-Build Alternative.

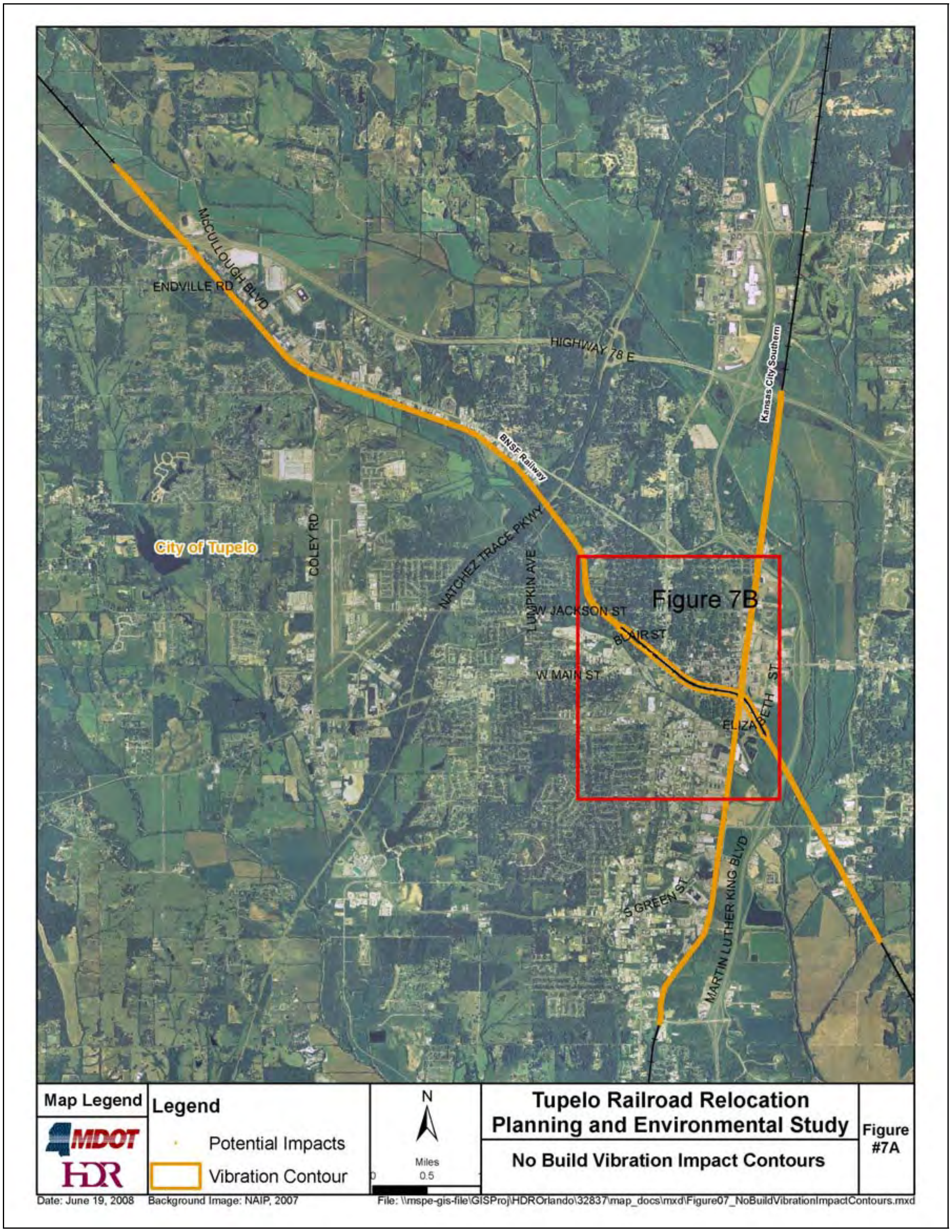


Figure 7 A-B. No-Build Vibration Impact Contour


MARSHALL ST
FLETCHER ST
CHESTER AVE
CALLOWAY ST
MAXWELL ST
HOUSTON ST
WOODLAWN ST
JOYNER AVE
CLAYTON AVE
MAGNOLIA ST
HIBNER DR
N GLOSTER ST
NORTH
WALKER ST
BARNES RD
REA ST
TOLBERT ST
N MADISON ST
N GREEN ST
HUNTER
HILDA AVE
HIGHWAY 45 N
HIGHWAY 45 S
W JACKSON ST
E JACKSON ST
N PARK ST
ALLEY
CHAPMAN DR
RANKIN BLVD
WALNUT ST
STARK ST
ALLEN ST
N CHURCH ST
N BROADWAY ST
N SPRING ST
N FRONT ST
COMMERCE ST
N INDUSTRIAL RD
KING ST
N HIGHLAND DR
NELLE ST
ROBINS ST
COURT ST
E MAIN ST
W MAIN ST
E TROY ST
S PARK ST
MAGAZINE ST
S BROADWAY ST
S HIGHLAND DR
STONE ST
MILFORD ST
S INDUSTRIAL RD
CARNATION ST
S CHURCH ST
S SPRING ST
FAIRPARK DR
ELLIOT ST
MAPLE ST
ELM ST
ELIZABETH ST
IDA ST
ROBERT E LEE DR
VARSITY DR
HOOVER ST
CHESTNUT ST
E PRESIDENT AVE
PIERCE ST
DAYBRITE DR
LAWNDALE DR
EISENHOWER DR
S GREEN ST
TYLER DR
HARRISON ST
VAN BUREN AVE
PLANT RD
FILLMORE DR
KENNEDY DR
PRESIDENT AVE
TAYLOR ST
S GLOSTER ST
COUNCIL CIR
CROSSOVER RD
GRANT ST
S MADISON ST
COMMUNITY DR
CLEVELAND ST
GARFIELD ST
PEGRAM DR
SERVICE DR
Private dr
Map Legend
MDOT
HDR
Legend
Potential Impacts
Vibration Contour
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Feet
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500
1,000
Tupelo Railroad Relocation Planning and Environmental Study
No Build Vibration Impact Contours
Figure #7B
Date: June 19, 2008
Background Image: NAIP, 2007
File: \\mspe-gis-file\GISProj\HDROrlando\32837\map_docs\mxd\Figure07_NoBuildVibrationImpactContours.mxd

B.

5.2.2 Alternative M

Forty-six (46) vibration impacts were identified under Alternative M. Table 7 summarizes the number of vibration impacts by location.

Figures 8A and 8B present vibration impact contours for Alternative M.

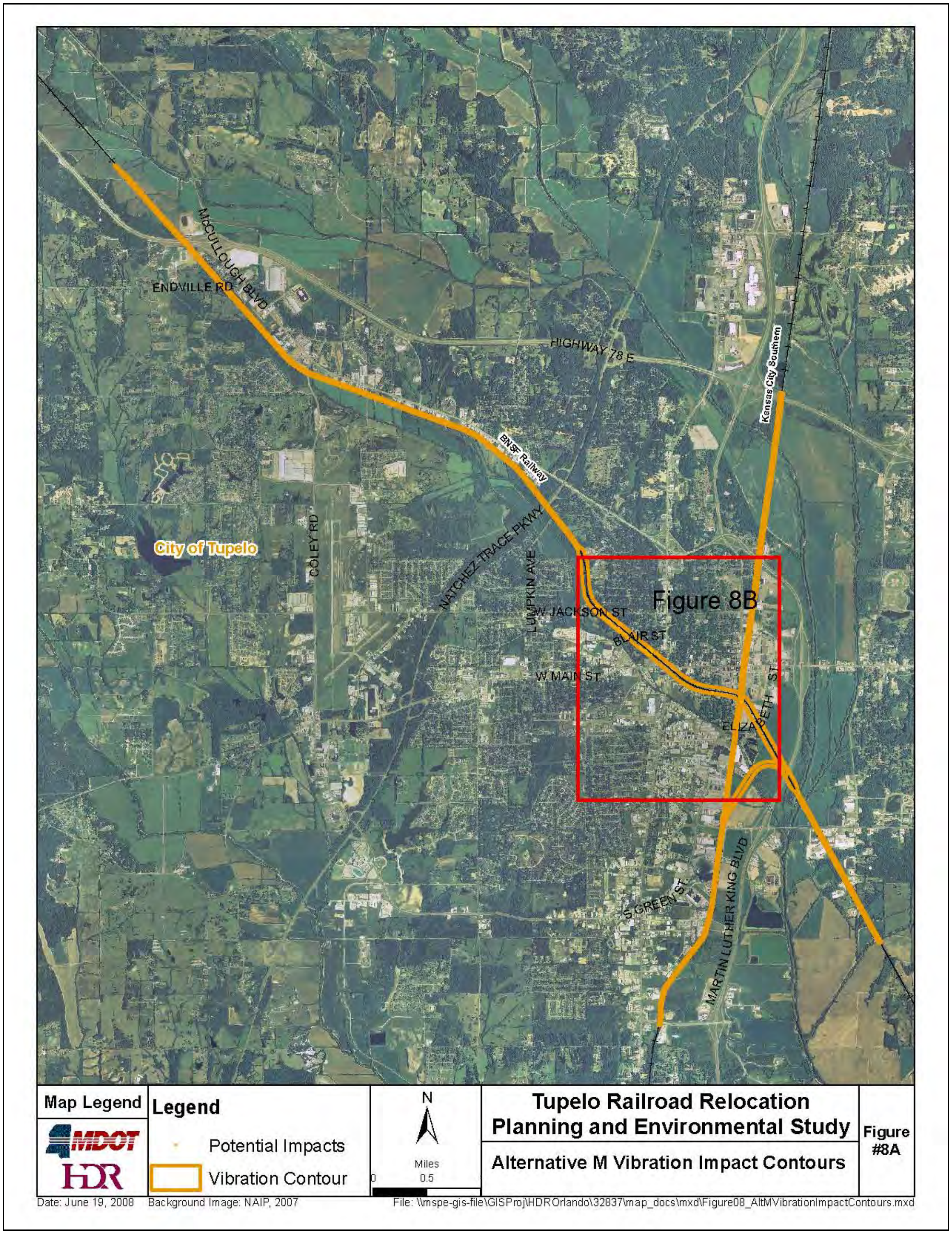
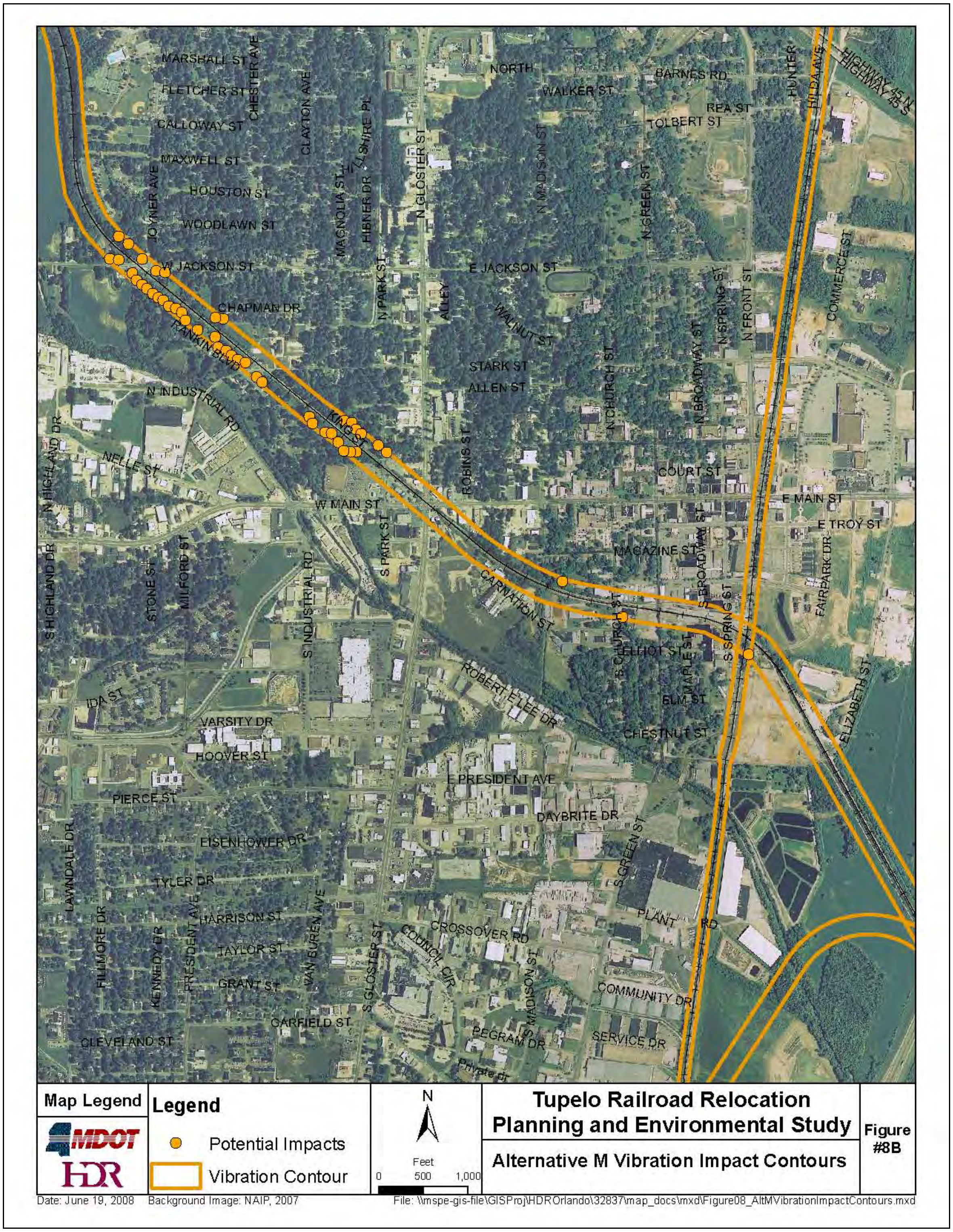


Figure 8 A-B. Alternative M – Vibration Impact Contours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FLETCHER ST
CHESTER AVE
CALLOWAY ST
CLAYTON AVE
MAXWELL ST
JOYNER AVE
HOUSTON ST
WOODLAWN ST
MAGNOLIA ST
HIBNER DR
N GLOSTER ST
N MADISON ST
N GREEN ST
NORTH
WALKER ST
BARNES RD
REA ST
TOLBERT ST
HUNTER
HILDA AVE
HIGHWAY 45 N
HIGHWAY 45 S
W JACKSON ST
E JACKSON ST
CHAPMAN DR
N PARK ST
ALLEY
WALNUT ST
STARK ST
ALLEN ST
N CHURCH ST
N BROADWAY ST
N SPRING ST
N FRONT ST
COMMERCE ST
RANKIN BLVD
N INDUSTRIAL RD
KING ST
N HIGHLAND DR
NELLE ST
ROBINS ST
COURT ST
E MAIN ST
E TROY ST
W MAIN ST
S PARK ST
MAGAZINE ST
FAIRPARK DR
S HIGHLAND DR
STONE ST
MILFORD ST
S INDUSTRIAL RD
CARNATION ST
S CHURCH ST
S BROADWAY ST
S SPRING ST
ELLIOT ST
MARLE ST
ELM ST
ELIZABETH ST
ROBERT E LEE DR
CHESTNUT ST
IDA ST
VARSITY DR
HOOVER ST
E PRESIDENT AVE
PIERCE ST
DAYBRITE DR
EISENHOWER DR
S GREEN ST
LAWNDALE DR
TYLER DR
HARRISON ST
PLANT RD
FILLMORE DR
KENNEDY DR
PRESIDENT AVE
TAYLOR ST
VAN BUREN AVE
S GLOSTER ST
COUNCIL CIR
CROSSOVER RD
GRANT ST
S MADISON ST
COMMUNITY DR
CLEVELAND ST
GARFIELD ST
PEGRAM DR
SERVICE DR
Private dr
Map Legend
MDOT
HDR
Legend
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Vibration Contour
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Feet
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Tupelo Railroad Relocation Planning and Environmental Study
Alternative M Vibration Impact Contours
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B.

5.2.3 Alternative L

One vibration impacts were identified under Alternative L. Table 7 summarizes the number of vibration impacts by location.

Figures 9A and 9B present vibration impact contours for Alternative L.

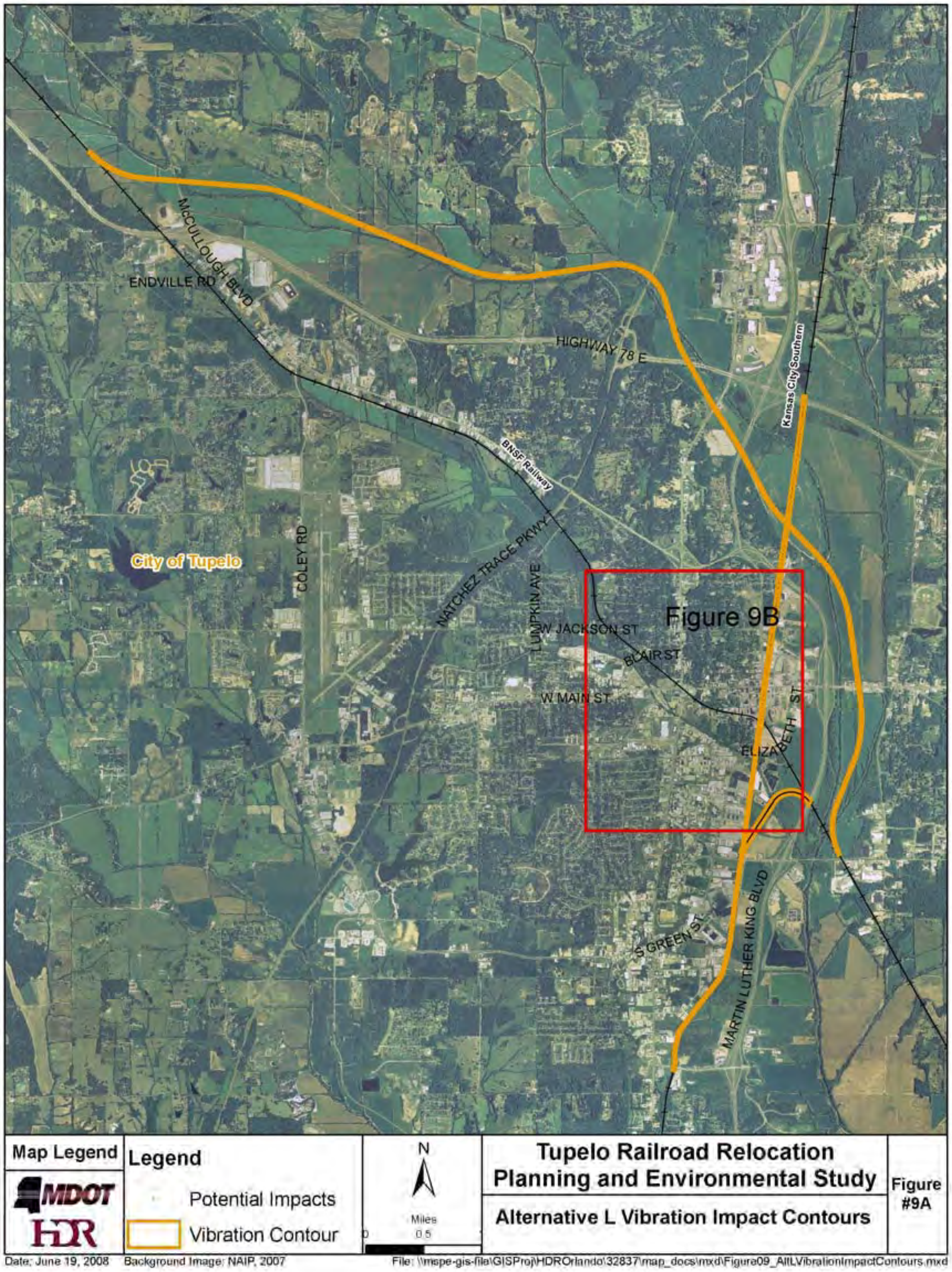


Figure 9 A-B. Alternative L Vibration Impact Contours


MARSHALL ST
FLETCHER ST
CHESTER AVE
CALLOWAY ST
CLAYTON AVE
MAXWELL ST
HOUSTON ST
JOYNER AVE
WOODLAWN ST
MAGNOLIA ST
HIENER DR
N GLOSTER ST
NORTH
WALKER ST
BARNES RD
REA ST
TOLBERT ST
HUNTER
HILDA AVE
HIGHWAY 45 N
HIGHWAY 45 S
N MADISON ST
N GREEN ST
W JACKSON ST
E JACKSON ST
N PARK ST
ALLEY
CHAPMAN DR
WALNUT ST
N SPRING ST
N FRONT ST
COMMERCE ST
RANKIN BLVD
STARK ST
ALLEN ST
N CHURCH ST
N BROADWAY ST
N INDUSTRIAL RD
KING ST
N HIGHLAND DR
NELLE ST
ROBINS ST
COURT ST
W MAIN ST
E MAIN ST
E TROY ST
S PARK ST
MAGAZINE ST
S HIGHLAND DR
STONE ST
MILFORD ST
S INDUSTRIAL RD
CARNATION ST
S BROADWAY
S SPRING ST
FAIRPARK DR
S CHURCH ST
ELLIOT ST
MAPLE ST
ELM ST
ELIZABETH ST
IDA ST
ROBERT E LEE DR
VARSITY DR
CHESTNUT ST
HOOVER ST
E PRESIDENT AVE
PIERCE ST
DAYBRITE DR
EISENHOWER DR
S GREEN ST
LAWNDALE DR
TYLER DR
PLANT RD
HARRISON ST
VAN BUREN AVE
CROSSOVER RD
FILLMORE DR
KENNEDY DR
PRESIDENT AVE
TAYLOR ST
S GLOSTER ST
COUNCIL CIR
GRANT ST
S MADISON ST
COMMUNITY DR
GARFIELD ST
CLEVELAND ST
PEGRAM DR
SERVICE DR
Private dr
Map Legend
Legend
MDOT
HDR
Potential Impacts
Vibration Contour
N
Feet
0 500 1,000
Tupelo Railroad Relocation
Planning and Environmental Study
Alternative L Vibration Impact Contours
Figure #9B
Date: June 19, 2008
Background Image: NAIP, 2007
File: \\mspe-gis-file\GISProj\HDROrlando\32837\map_docs\mxd\Figure09_AltLVibrationImpactContours.mxd

B.

Table 7. Summary of FTA Land Use Vibration Impacts Predicted for No Build and Build Alternatives

Alternative	Predicted Category 2 Vibration Impacts	Predicted Category 3 Vibration Impacts Operational Connection between BNSF & KCS
No-Build	28	NA[1]
Alternative M	46	0
Alternative L	1	0

1. Not applicable.

Analysis results show that predicted vibration velocity levels associated with Alternative M reach FTA's vibration impact threshold at 18 additional receptors than are predicted to occur under the No-Build Alternative. The increase in the number of predicted vibration impacts is due to the increase in train speed, from 20 mph to 40 mph.

Analysis results also show that predicted vibration velocity levels associated with Alternative L reach FTA's vibration impact threshold at 1 receptor. The predicted impact exists immediately adjacent to the BNSF-KCS intersection, and also occurs under Alternative M.

APPENDIX A. FUNDAMENTALS OF NOISE AND VIBRATION

Fundamentals of Noise

Sound is mechanical energy transmitted by pressure waves in a compressible medium such as air. Noise is generally defined as unwanted or excessive sound. Sound can vary in intensity by over one million times within the range of human hearing. Therefore, a logarithmic scale, known as the decibel scale (dB), is used to quantify sound intensity and to compress the scale to a more manageable range.

Sound is characterized by both its amplitude and frequency (or pitch). The human ear does not hear all frequencies equally. In particular, the ear deemphasizes low and very high frequencies. To better approximate the sensitivity of human hearing, the A-weighted decibel scale (dBA) has been developed. On this scale, the human range of hearing extends from approximately 3 dBA to around 140 dBA. Figure 10 shows a range of typical noise levels from common indoor and outdoor activities.

Using the decibel scale, sound levels from two or more sources cannot be directly added together to determine the overall sound level. Rather, the combination of two sounds at the same level yields an increase of 3 dB. The smallest recognizable change in sound level is approximately 1 dB. A 3-dB increase in the A-weighted sound level is generally considered noticeable, whereas a 5-dB increase is readily noticeable. A 10-dB increase is judged by most people as an approximate doubling of the perceived loudness.

The two primary factors that reduce levels of environmental sounds are increasing the distance between the sound source and the receiver and having intervening obstacles such as walls, buildings, or terrain features that block the direct path between the sound source and the receiver. Factors that act to make environmental sounds louder include moving the sound source closer to the receiver, sound enhancements caused by reflections, and focusing caused by various meteorological conditions.

Below are brief definitions of the measurements and other terminology used in this report:

- Root Mean Square (RMS): The average of the squared amplitude of the vibration signal. The amplitudes of sound are almost always given in terms of the RMS sound level.
- Equivalent Sound Level (Leq): Environmental sound fluctuates constantly. The equivalent sound level (Leq), sometimes referred to as the energy average sound level, is the most common means of characterizing community noise. Leq represents a constant sound that, over the specified period, has the same sound energy as the time-varying sound.
- Maximum Sound Level (Lmax): Lmax is the maximum sound level over the measurement period. Sound level meters usually have a selector for measuring sound with either the fast or slow meter setting, which represent time constants of 0.25 and 1 second respectively. Lmax measured using the fast meter setting will typically be 1 to 3 decibels higher than when measured using the slow meter setting. If not stated, the term Lmax is usually taken to indicate the fast sound level meter setting.
- Sound Exposure Level (SEL): SEL describes a receiver’s cumulative noise exposure from a single noise event. It is represented by the total A-weighted sound energy during the event, normalized to a one-second interval. SEL is used in the FRA manual on high-speed train noise to define thresholds for noise impact on wildlife. It is also a useful intermediate quantity for estimating Ldn from train pass bys.

- Day-Night Sound Level (Ldn): Ldn is basically a 24-hour Leq with an adjustment to reflect the greater sensitivity of most people to nighttime noise. The adjustment is a 10-dB penalty for all sound that occurs between the hours of 10 p.m. and 7 a.m. The effect of the penalty is that, when calculating Ldn, any event that occurs during the nighttime is equivalent to 10 of the same event during the daytime. Ldn is the most common measure of total community noise over a 24-hour period and is used by the Federal Transit Administration (FTA) to evaluate residential noise impacts from proposed transit projects.

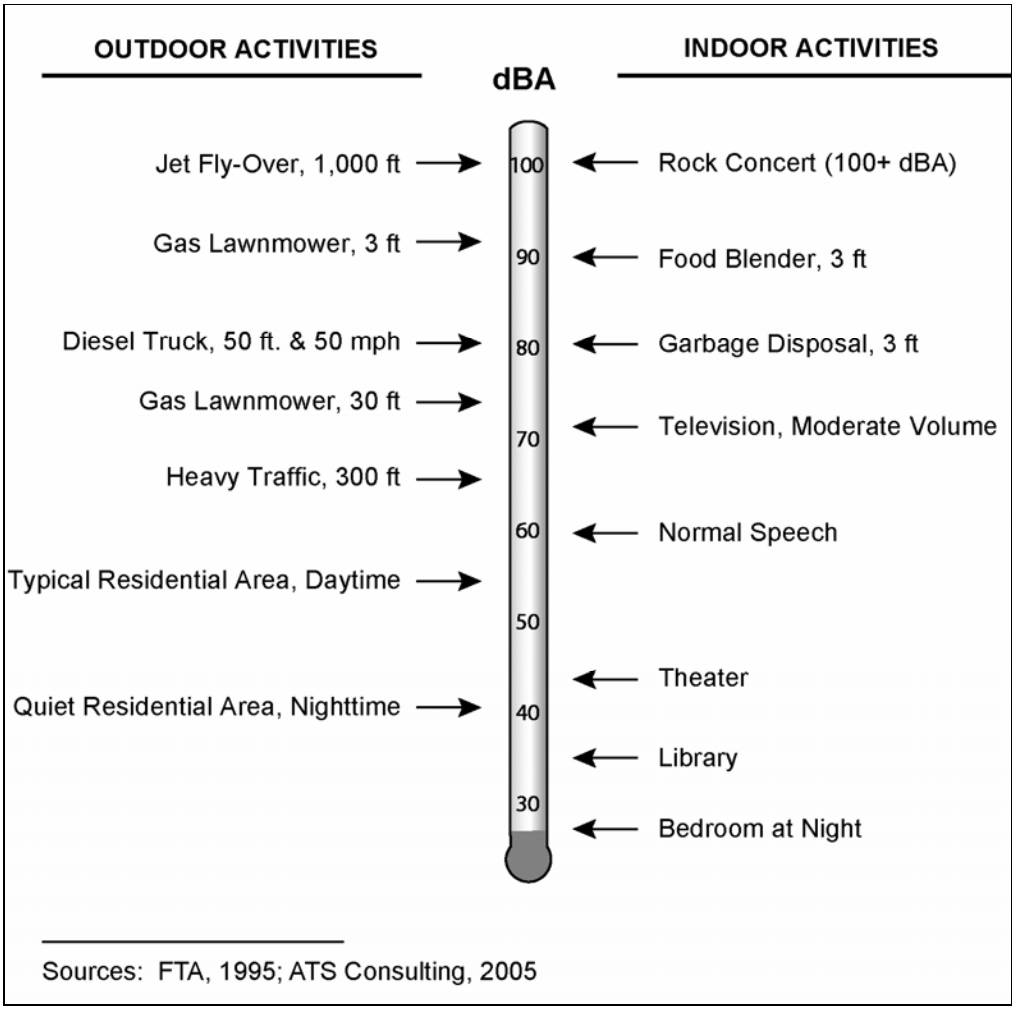


Figure 10. Graph of Typical Indoor & Outdoor Noise Sources and Levels

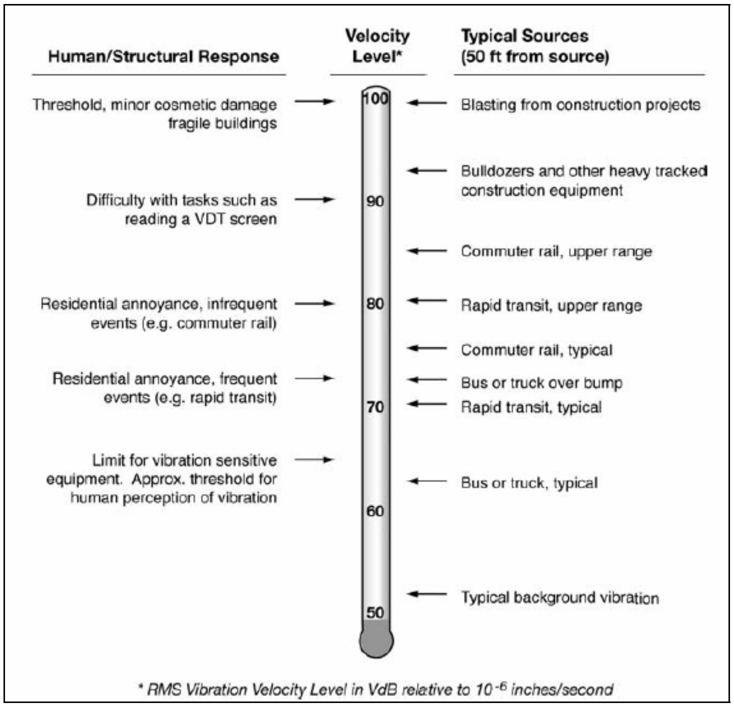
Fundamentals of Vibration

Vibration is an oscillatory motion that can be described in terms of displacement, velocity, or acceleration. The response of humans to vibration is very complex. However, the general consensus is that for the vibration frequencies generated by sources such as rail trains, human response is best approximated by the vibration velocity level. Therefore, vibration velocity has been used in this study to describe train-generated vibration levels.

Train-generated vibration, which is caused by the interaction of the wheels and rails, may be perceived by building occupants as perceptible vibration. It is also common for ground-borne vibration to cause windows, pictures on walls, or items on shelves to rattle. Although the perceived vibration from train pass bys can be intrusive to building occupants, the vibration is almost never of sufficient magnitude to cause even minor cosmetic damage to buildings.

When evaluating human response, ground-borne vibration is usually expressed in terms of root mean square (RMS) vibration velocity. RMS is defined as the average of the squared amplitude of the vibration signal.

Figure 11 shows typical vibration levels from rail and non-rail sources as well as the human and structure response to such levels. The threshold of perception for most people is around 65 VdB. Vibration levels below 72 VdB are often noticeable but acceptable and levels in excess of 80 VdB are often considered unacceptable.



Source: FTA, 2006

Figure 11. Typical Vibration Levels

APPENDIX B. PHOTOS OF 24-HOUR SOUND MEASUREMENT SITES

SITE 1. 337 KING STREET

SITE 2. 330 RANKIN BOULEVARD

SITE 3. MADISON ARMS APARTMENTS, 130 MADISON AVENUE

SITE 4. HEARDTOWN ESTATES, COUNTY ROAD 1740

SITE 5. 1505 TRACE AVENUE

APPENDIX C. MEASUREMENT PROCEDURES AND EQUIPMENT

The noise measurements discussed in this report were all performed with measurement equipment that is in conformance with ANSI S1.4-1983 Type 1, ANSI S1.43-1997 Type 1, IEC 60651 type 1, IEC 60804 type 1 and IEC 61672-1, class 1. An acoustic calibrator was used to check the instrument calibrations immediately before and after each noise measurement.

HDR used Larson Davis 820 sound level meters to record the 24-Hour continuous measurements at the seven sites that represent the project area. At the completion of each measurement, the data was downloaded, converted to a text file and imported to an Excel spreadsheet for analysis.

The short-term noise measurements were performed using Larson Davis 824 and 812 sound level meters. Sound Exposure levels were measured during train pass bys.